EVALUATION OF THE MANAGEMENT PLAN FOR PENAEID SHRIMPS IN THE CONTINENTAL SHELF OF SERGIPE, BRAZIL*

Rafael de Carvalho SANTOS[1], Sonja Luana Rezende da SILVA[1], Rogério Caetano da COSTA[2], Thiago Maia DAVANSO[2], Gustavo Luis HIROSE[1]

ABSTRACT

This study evaluated if the temporal and spatial reproduction and recruitment of the main species of marine shrimps exploited in the state of Sergipe (*Xiphopenaeus kroyeri*, *Farfantepenaeus subtilis*, and *Litopenaeus schmitti*) are being protected, in relation to the closed season based on the normative instruction MMA n° 14, of October 14th 2004. The samples were collected monthly from September 2013 to August 2014 at the continental shelf of Sergipe, in nine transects, distributed in the depths of 5, 15, and 30 m using a shrimping boat equipped with double ring nets. After sampling, we identified shrimps to the species level; subsampled, sexed them, measured carapace length, and observed the gonads. Recruitment and reproduction in the three species occur continuously, albeit with intensity peaks. Regarding space, reproductive individuals and recruits were more abundant at 30 m in the case of *F. subtilis*, while for *X. kroyeri* and *L. schmitti*, higher abundances were found at 5 and 15 m. The current normative instruction partially protects the reproductive and juveniles categories of these species, mainly *F. subtilis*. Thus, we suggest closed seasons at breeding and recruitment seasons of *F. subtilis*, since the area set by IBAMA already protects other species throughout the year.

Key words: *Xiphopenaeus*; *Farfantepenaeus*; *Litopenaeus*; recruitment; reproductive period; fishery.

AVALIAÇÃO DO PLANO DE MANEJO DE CAMARÕES PENEÍDEOS NA PLATAFORMA CONTINENTAL DE SERGIPE, BRASIL

RESUMO

Este estudo avaliou se a reprodução e o recrutamento temporal e espacial das principais espécies de camarões marinhos explotados no Estado de Sergipe (*Xiphopenaeus kroyeri*, *Farfantepenaeus subtilis* e *Litopenaeus schmitti*) estão sendo protegidos, em comparação com normativa MMA nº 14, de 14 de outubro de 2004. As coletas foram realizadas de setembro/2013 a agosto/2014 na plataforma continental de Sergipe, em nove transectos, distribuídos nas profundidades de 5, 15 e 30m, utilizando um barco camaroeiro equipado com rede de arrasto de portas. Após as coletas os indivíduos foram identificados ao nível específico, subamostrados, sexados, mensurados quanto ao comprimento da carapaça e classificados quanto à morfologia gonadal. O recrutamento e a reprodução das três espécies ocorreram continuamente ao longo do ano, apresentando picos de intensidade. Indivíduos reprodutivos e juvenis foram mais abundantes nos 30m para *F. subtilis*, enquanto para *X. kroyeri* e *L. schmitti* foram mais abundantes nos 5m e 15m. A atual instrução normativa protege parcialmente as categorias reprodutivas e juvenis dessas espécies, principalmente *F. subtilis*. Portanto, sugere-se a adequação dos períodos de defeso para as épocas de reprodução e recrutamento de *F. subtilis*, uma vez que a área estipulada pelo IBAMA já protege as demais espécies ao longo do ano.

Palavras chave: *Xiphopenaeus*; *Farfantepenaeus*; *Litopenaeus*; recrutamento; período reprodutivo; pesca.

Artigo Científico: Recebido em 29/09/2016; Aprovado em 17/02/2017

[1]*Departamento de Biologia, Universidade Federal de Sergipe, Av. Marechal Rondon, s/n°, Rosa Elze, 49100-000, São Cristóvão SE, Brasil. E-mail: rafa_bio@hotmail.com.br (corresponding author)*

[2]*Departamento de Ciências Biológicas, Faculdade de Ciências, UNESP, Av. Luis Edmundo Carrijo Coube, 14-01, Vargem Limpa, 17033-360, Bauru, SP, Brasil.*

**Financial support: CNPq and CAPES.*

INTRODUCTION

The shrimps of the family Penaeidae Rafinesque, 1815 are considered one of the most exploited fishing resources in coastal regions over the world (ALBERTONI *et al.*, 2003; COSTA *et al.* 2007; EUTRÓPIO *et al.*, 2013). At the Brazilian coast, five species distributed in three genera represent the shrimps with greatest economic importance, the seabob shrimp *Xiphopenaeus kroyeri* (Heller, 1862), the white shrimp *Litopenaeus schmitti* (Bukenroad, 1936), and the pink shrimp *Farfantepenaeus subtilis* (Pérez-Farfante, 1967), *F. brasiliensis* (Latreille, 1817) and *F. paulensis* (Pérez-Farfante, 1967).

In the northeast of Brazil, fishery mainly focuses on the stocks of the seabob shrimp *X. kroyeri*, the white or pistol shrimp *L. schmitti*, and the pink shrimp *F. subtilis* (SANTOS, 2010a). In production terms, the marine shrimps are main fishing resources of the Sergipe State at 2010, 2011 and 2013, and the second most important in 2012 (Thomé-Souza *et al.* 2012, 2013, 2014a, 2014b). The specie *X. kroyeri* has the higher importance in fishery production of the Sergipe state, while the species *F. subtilis* and *L. schmitti* are less abundant; however present high commercial value due the higher sizes in comparison to *X. kroyeri* (Thomé-Souza *et al.* 2012, 2013, 2014a, 2014b). The species mentioned above have being constantly found among the Penaeoidea shrimps exploited through motorized artisanal fishing at Sergipe State, with weight participation, respectively, of 85.5%, 8.4% and 6.1% for *X. kroyeri*, *F. subtilis* and *L. schmitti* (Santos *et al*. 2007). Thus, these shrimps are considered of high economic, historic, social, and cultural importance (BRANCO, 2005), and the current fishing methods result in overexploitation of marine shrimps, mainly in coastal regions (PAULY *et al.*, 2002).

Management plans which aim to control the commercial exploitation of crustacean species in Brazil are based on a set of proposals designated to preserve a sufficient stock size for appropriate recruitment and to prevent the catch of individuals in critical phases in their life cycle (juveniles and reproductive categories) (DIAS-NETO, 2011). The current management plan stipulated for the State of Sergipe is based on the normative instruction MMA (“Ministério do Meio Ambiente”) n° 14, of the 14th October 2004, which prohibits fishing of *X. kroyeri*, *F. subtilis*, *F. brasiliensis*, and *L. schmitti* in areas from the state boundary of Pernambuco and Alagoas State to the border of the municipalities of Mata de São João and Camaçari at Bahia State from April 1st to May 15th and from December 1st to January 15th; in addition, fishing is banned in areas closer than two nautical miles (about 3.7 km) from the coast (BRASIL, 2004a).

Previously, the closed area comprised a larger extension. According to the described SUDEPE (“Superintendência de Desenvolvimento de Pesca”) ordinance n° N-62, from December 14th 1983, the Sergipe State was determined to ban fishing at less than three nautical miles from the coast (SANTOS, 2010a). This change occurred based on the shelf characteristics and was aimed at the conservation of the sea turtle, since the accidental catch of sea turtles due the shrimp fishery is one of the leading causes of their death (SILVA *et al.*, 2010; SANTOS *et al.*, 2013). This change occurred through the project denominated ”Determinação dos parâmetros Biológicos e Pesqueiros das Populações de Camarões Peneídeos Capturados no Estado de Sergipe”, organized by CEPENE (“Centro de Pesquisa e Gestão de Recursos Pesqueiros do Litoral Nordeste”), with support of the “Centro TAMAR (“Projeto Tartaruga Marinha”)”, SUPES/IBAMA/SE (“Superintendência de Estudos e Pesquisas/Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis/ Sergipe”), CONATURA (“Cooperativa Mista dos Trabalhadores Conservadores da Natureza, Ltda.”), PETROBRAS (“Petróleo Brasileiro S.A.”) e CONDEPI (“Conselho de Desenvolvimento Comunitário de Pirambu”) (SANTOS, 2010a).

It is important to highlight that the current management plan does not distinct the different species of marine shrimps commercially caught, in relation to the closed seasons stipulated or fishing exclusion areas. The lack of information about the biology of the captured species hinders the comprehension of their biological cycles and the development of adequate management plans. According to the normative instruction MMA n° 5, from May 21st 2004, the species of the present study are overexploited in the southern and southeastern parts of Brazil (BRASIL, 2004b).

For northeastern Brazil, the species *X. kroyeri* is classified as moderately exploited (VASCONCELLOS *et al.*, 2007), while for the other species, information is scarce.

Besides their commercial importance, the shrimps are also considered structural elements of benthic communities and play a role in predation and competition as well in bioturbation of superficial sediments (DELEO and PIRES-VANIN, 2006). Thus, the disordered fishing and inadequate management plans can disorganize biological communities part of these organisms, often irreversibly breaking trophic links (MANTELATTO and FRANSOZO, 1999). Therefore, knowledge about population aspects, such as reproduction and juvenile recruitment, can improve evaluation and/or adequacy of management plans that efficiently protect the penaeid shrimp population from being commercially overexploited.

The objective of the present study was to evaluate temporal and spatial reproduction and recruitment of the main commercially exploited species of penaeid shrimps in the State of Sergipe, and test the null hypothesis that these species share a synchronous recruitment and reproductive period, once there is no clear distinction among species in the current management plan. Then, we confronted the obtained data with the closed season period and the fishing excluded area, in order to evaluate the efficiency of the species' protection during the critical phases in their life cycles.

METHODS

The continental shelf of Sergipe is considered one of the narrower shelves of Brazil (PEREIRA *et al*., 2014), shallow and with reduced width, ranging between 12 and 34.9 km with a gentle slope (1:1000) (LEMOS-JUNIOR *et al*. 2014). The coastal zone of Sergipe presents a coastline of 163 km and is confined by the São Francisco river mouth, which separates the Alagoas State, in the north and the Piauí-Fundo-Real estuarine complex mouth, which separates the Bahia State, in the south (CARVALHO and FONTES, 2007).

Sampling in the continental shelf was conducted monthly from September 2013 to August 2014 at the area situated between the Sergipe and Vaza-Barris Rivers mouths (Figure 1). We established nine sampling transects, distributed at depths of 5, 15, and 30 m. It is worth mentioning that the transects at 5 m lies within the protected area; according to the current management plan (normative instruction MMA n°14, of October 14th 2004), where motorized dragging within two nautical miles from the coast is prohibited. The transects at 15 m lies on the threshold of this protected area, while the ones at 30 m depth is outside this area.

Shrimp fishing was performed using a shrimping boat with double ring nets of the following measurements: 4 m mouth wide, 10 m long, 20 mm mesh internode distance at sleeves and the body network, and 18 mm internode distance in the bag. In each transect, dragging was performed for a period of 15 minutes. All sampled material was stored in plastic bags inside thermal boxes with ice and transported to the laboratory. We also determined the following environmental factors: temperature (surface and bottom), salinity (surface and bottom), and sediment (organic matter content and granulometry).

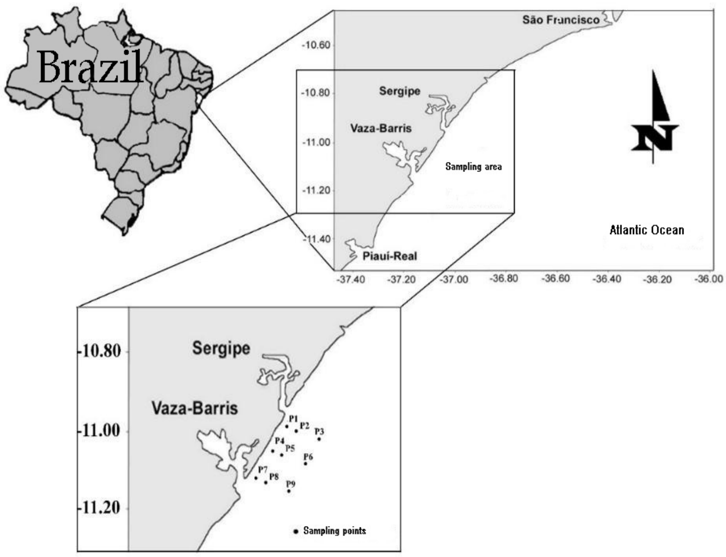

Figure 1. Map of the marine area of the continental shelf of Sergipe, situated at the height of the Sergipe and Vaza-Barris Rivers mouths. Points P1 to P9 represent the sampling transects.
Fonte: Elaborado por Gustavo Luis Hirose

Superficial water samples were collected with a plastic recipient (5 L); temperature was measured using a mercury-in-glass thermometer (°C) and the salinity by an optical refractometer (Ref 211 0-100%). The bottom water samples were collected with a Van Dorn bottle (5 L). Immediately after collecting the bottom water, the same procedure used for determining the temperature and salinity of the surface water was used. Samples for the determination of superficial and bottom temperature and salinity were obtained from each sample site. Sediment samples were obtained from each site using a Van Veen grab (0.06 m^2). Organic matter content (%) was determined through ash-weighting, according to the method described by MANTELATTO and FRANSOZO (1999), these values were obtained using subsamples of 10 g substrate of each transect, each month. The granulometric analysis were conducted after desalination and drying (60°C) of sediment during 24h, thereafter, subsamples of 100 g of each transect underwent a differential sieving technique in a set of six sieves with different mesh openings through a shaker, for 10 minutes. Sediment granulometric values were obtained following the pattern proposed by WENTWORTH (1922); we then calculated the central sediment tendency (PHI), determining the dominant granulometric fraction of the sediment (SUGUIO, 1973).

In the laboratory, the shrimps were identified according to COSTA *et al*. (2003) and then weighted (total biomass in grams). A subsample of 300 g was taken randomly for each transect if any specimen exceeded a weight of 300 g. The subsampled shrimps were identified in relation to sex and carapace length (CL mm) was measured using digital calipers (0.01 mm of precision). Total abundance of individuals was extrapolated from the total biomass and based on the number of subsampled individuals for each species separately. The individuals from both sexes were separated into juveniles and adults. Reproductive condition of females was determined by macroscopic observation of the gonads, with the ovaries being categorized according to color and size (BAUER and LIN, 1994; NAKAGAKI and NEGREIROS-FRANSOZO, 1998; COSTA and FRANSOZO, 2004, CASTILHO *et al*., 2007). We classified four developing stages: immature female (IM) with fine, transparent, and small ovaries; female with gonads in development (ED) with light green ovaries; female with developed gonads (DE) with dark green, easily visible and voluminous ovaries, and females with rudimentary gonads (RU) with transparent ovaries, but carapace length higher than in the smallest female DE. Juvenile females were defined from sizes below the smallest female with mature gonads.

For males, we followed the pattern proposed by BOSCHI and SCELZO (1977), in which male classification was based on the merge of the petasma (endopod of the first abdominal appendage). The individuals were classified as juveniles (IM) when the endopod of the first pleopod pair was found disunited and as adults when the petasma was united. Besides that, adult males were classified as developed (DE) when they presented full terminal ampoules and as rudimentary (RU) when the terminal ampoule was empty. (NAKAGAKI and NEGREIROS-FRANSOZO, 1998).

Reproduction and recruitment

The monthly recruitment analysis was calculated by the percentages of juveniles (not discriminating sex) in relation to adults for each species. In the monthly reproductive period of females we calculated the percentage of reproductive females (ED + DE) in relation to the total of adult females for each species separately (BAUER and RIVERA-VEGA, 1992; BAUER and LIN, 1994). The same routine used for determinate the percentage of females was used for males (DE). In relation to depth the abundance of juvenile and reproductive males, and females at the different depths (5, 15 and 30 m) were calculated through the percentage of these demographic categories in relation to the total of individuals catch for each species.

Spatio-temporal distribution

The data used for distribution analysis were tested for normality using the Shapiro-Wilk test ($\alpha = 0.05$) and for homoscedasticity using the Levene test ($\alpha = 0.05$). The test results showed that these data do not meet the assumptions of a parametric test, then they were log-transformed (log (x+1)). Even after the data transformation, they remained non-normal and non-homocedastic (Table 1), and then a non-parametric test was applied. Spatial and temporal comparison were performed using the Kruskal-Wallis test (Kruskal-Wallis, $\alpha = 0.05$) in order to verify possible differences in the abundance of

Table 1. Results of Shapiro-Wilk (normality) and Levene (homoscedasticity) tests applied to the log(x+1) transformed variables in the present study.

Species	Variables	Shapiro-Wilk		Levene	
		W	p	F	p
X. kroyeri	Juvenile	0.85	<0.01	3.33	<0.01
	Female (ED + DE)	0.88	<0.01	4.56	<0.01
	Reproductive (Female + Male)	0.95	<0.01	0.80	0.75
F. subtilis	Juvenile	0.56	<0.01	9.77	<0.01
	Female (ED + DE)	0.51	<0.01	7.39	<0.01
	Reproductive (Female + Male)	0.71	<0.01	8.66	<0.01
L. schmitti	Juvenile	0.70	<0.01	7.78	<0.01
	Female (ED + DE)	0.47	<0.01	8.14	<0.01
	Reproductive (Female + Male)	5.19	<0.01	0.66	<0.01

juvenile and reproductive individuals among months and depth. For both analyses, *a posteriori* Dunn´s test (α = 0.05) was performed to detect significant differences between depths and months.

After the obtaining of the recruitment and reproductive period, the data was compared monthly with the two closed seasons determined by the normative instructions MMA n° 14, of October 14th 2004 (first from April 1st to May 15th and the second from December 1st to January 15th). The same routine was adopted in relation to the spatial distribution of juveniles and reproductive individuals, comparing the obtained data with the fishing exclusion area stipulated by the same normative instruction.

RESULTS

Characterization of the studied area

Mean temperatures in the study were high, especially in May (32.55 ± 1.81ºC at the surface and 32.33 ± 0.86ºC at the bottom), and variation throughout the year was low (Table 2). The same pattern was found for salinity, although with higher stratification between surface and bottom and higher surface values in April 2014 (38.11 ± 1.26) and bottom values in May 2014 (40.00 ± 1.11) (Table 2). In the sediment, we found high values of organic content, mainly in deeper regions. For terms of granulometry, there was a predominance of fine sand, except for the transects at 30 m depth, in which coarse sand and rubble were predominant (Table 3).

Group characterization

A total of 58,349 shrimps were sampled, of which *X. kroyeri* was most abundant (96%) and *F. subtilis* and *L. schmitti* least abundant (3 and 1%, respectively). We subsampled a total of 7,998 shrimps: 6,418 individuals of X. kroyeri (3,457 females and 2,961 males), 1,076 individuals of *F. subtilis* (658 females and 418 males), and 504 individuals of *L. schmitti* (296 females and 208 males) (Table 4). The higher total abundances for each species were found in September 2013 (n = 9,475), October 2013 (n = 7,592) and June 2014 (n = 8,811) for *X. kroyeri*; October 2013 (n = 222), July 2014 (n = 260) and August 2014 (n = 214) for *F. subtilis*; and December 2013 (n = 105) and May 2014 (n = 77) for *L. schmitti* (Figure 2 A). In relation to depth, *X. kroyeri* and *L. schmitti* were more abundant at 15 m (n = 28,385 and n = 225, respectively), while *F. subtilis* was most abundant at 30 m (n = 1,040) (Figure 2 B).

Recruitment and juvenile distribution

For *X. kroyeri* we observed a period of greater intensity from September to December 2013 (frequency values between 7 and 10%) (Figure 3 A). Juvenile individuals of *X. kroyeri* were sampled throughout the study period, with abundances differing significantly between months (Kruskal-Wallis, H = 38.66; p < 0.01) (Figure 3 B). Recruitment of *F. subtilis* was continuous throughout the year, except for December 2013 and July 2014, when we did not catch any juvenile individuals. However, there was a period with higher recruitment frequency from January to May 2014 (between 15 and 31%) (Figure 3 A). Juvenile abundance of *F. subtilis* was not significantly different between the sampled months (Kruskal-Wallis, H = 13.15; p = 0.28) (Figure 3 B). Juvenile individuals of *L. schmitti* did not occur in

Table 2. Average values and standard deviation from the hydrological factors sampled from September2013 to August 2014 in the continental shelf of Sergipe.

Month	A.s.t. ± S.D.	A.b.t. ± S.D.	A.s.s. ± S.D.	A.b.s. ± S.D.
Sep/13	27.44 ± **0.52**	27.44 ± **0.52**	36.22 ± **0.66**	38.22 ± **1.92**
Oct/13	27.27 ± **0.61**	26.55 ± **0.72**	35.22 ± **0.44**	37.33 ± **1.32**
Nov/13	26.88 ± 0.48	26.72 ± 0.50	37.33 ± 0.86	37.77 ± 0.83
Dec/13	27.66 ± **0.50**	27.27 ± **0.79**	36.44 ± **0.52**	36.80 ± **0.60**
Jan/14	28.33 ± **0.51**	27.33 ± **0.51**	35.33 ± **0.81**	36.16 ± **0.75**
Feb/14	28.61 ± **0.33**	27.77 ± **0.56**	35.88 ± **0.78**	36.88 ± 1.83
Mar/14	28.44 ± **0.72**	27.66 ± **1.00**	34.66 ± **1.73**	36.33 ± **0.86**
Apr/14	28.55 ± 0.72	27.55 ± **0.52**	38.11 ± **1.26**	39.00 ± **0.70**
May/14	32.55 ± **1.81**	32.33 ± **0.86**	36.00 ± **2.06**	40.00 ± **1.11**
Jun/14	30.44 ± **1.42**	30.33 ± **1.58**	35.55 ± **1.01**	37.77 ± **1.30**
Jul/14	30.22 ± **1.92**	28.77 ± **1.92**	35.00 ± **1.00**	35.77 ± **1.09**
Aug/14	30.00 ± **1.11**	28.77 ± **0.97**	37.77 ± **1.71**	39.00 ± **0.86**

A.s.t. = Average surface temperature; A.b.t. = Average bottom temperature; A.s.s. = Average surface salinity; A.b.s. = Average bottom salinity; S.D. = Standard Deviation.

Table 3. Mean values and standard deviation of the sediment characteristics at 5 m (P1, P4, and P7), 15 m (P2, P5, and P8), and 30 m (P3, P6, and P9) in the continental shelf of Sergipe.

Transect	Organic matter (%)	Phi
	Mean ± S.D.	Mean ± S.D.
P1	3.40 ± **3.14**	3.34 ± **0.58**
P2	1.99 ± **0.77**	3.33 ± **0.36**
P3	3.59 ± **2.53**	1.33 ± **1.43**
P4	3.30 ± **3.34**	2.91 ± **1.37**
P5	3.44 ± **3.23**	3.23 ± **0.71**
P6	6.29 ± **4.41**	2.35 ± **0.99**
P7	1.48 ± **0.62**	3.63 ± **0.13**
P8	4.40 ± **2.70**	2.63 ± **1.77**
P9	7.25 ± **5.35**	1.23 ± **1.58**

Phi = Central sediment tendency; S. D. = Standard Deviation.

Table 4. Descriptive statistics of crab size (CW in mm) according to sex of each specie sampled.

Species	Category	N	M.S ± SD	Max Size	Min Size
X. kroyeri	Female	3,457	18.21 ± **3.77**	30.41	7.00
	Male	2,961	16.74 ± **2.49**	29.07	7.51
F. subtilis	Female	658	23.14 ± **5.58**	42.55	11.05
	Male	418	19.81 ± **2.83**	32.64	11.95
L. schmitti	Female	296	22.53 ± **4.31**	39.30	11.79
	Male	208	22.50 ± **3.23**	33.08	15.78

N = number of individuals; M.S. = Mean Size; S.D. = Standard Deviation; Max Size = Maximum Size; Min Size = Minimum Size.

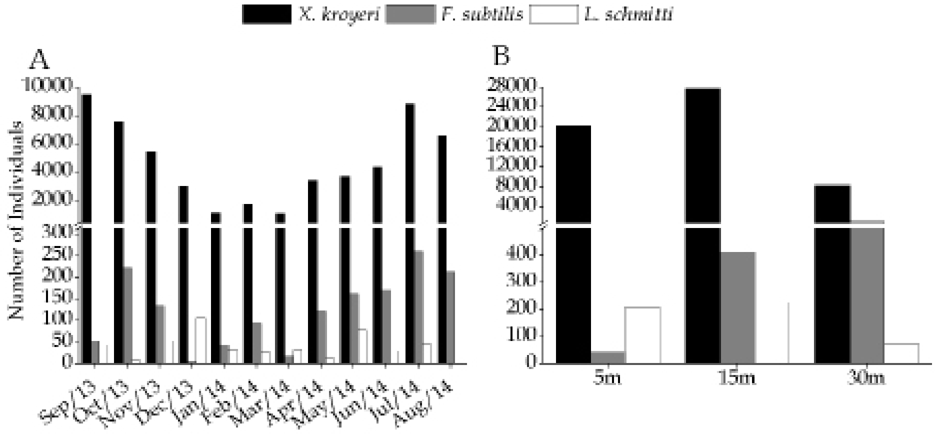

Figure 2. A. Number of individuals of exploited Penaeid shrimps sampled at the continental shelf of Sergipe along months. B. Number of individuals of exploited Penaeid shrimps sampled at the different depths.

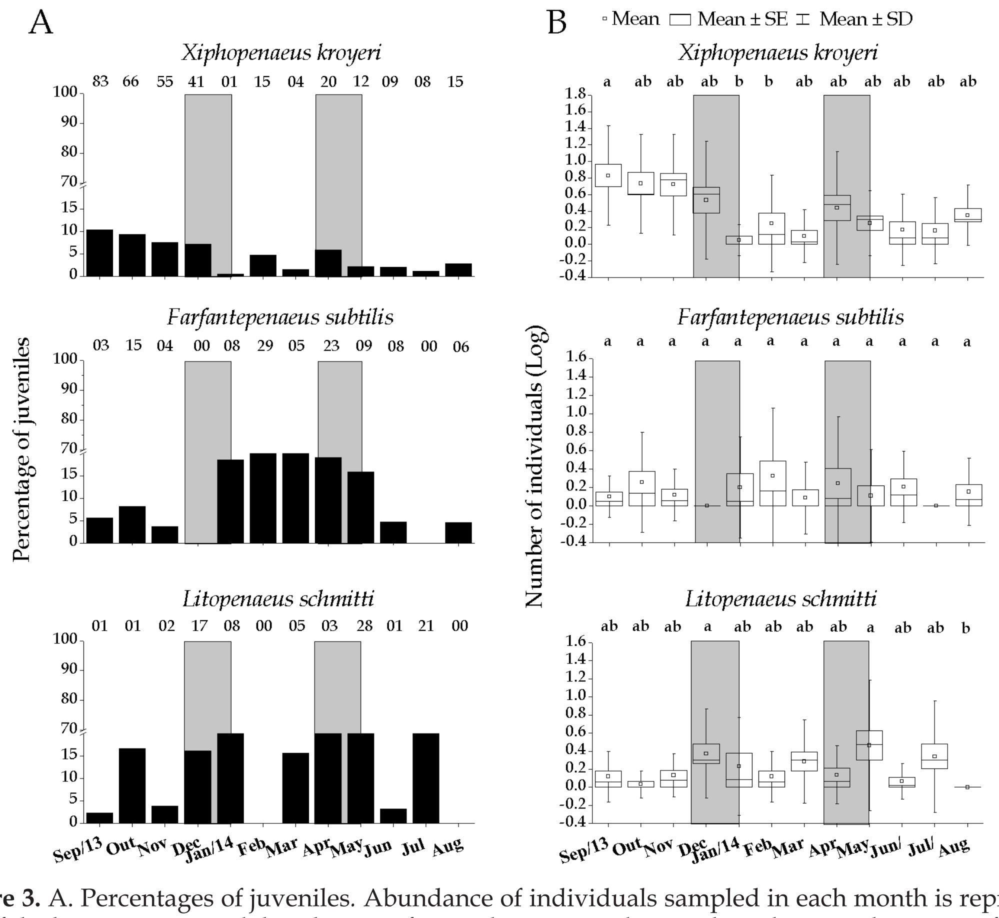

Figure 3. A. Percentages of juveniles. Abundance of individuals sampled in each month is represented at the top of the bars. B. Temporal distribution of juveniles. Distinct letters above boxes indicate significant statistical differences (Dunn's test α = 0.05). The highlighted bars in gray indicate the months evaluated in the current closed season (normative instructions MMA n° 14, of October 14th 2004).

February and August 2014. In relation to frequency, two periods of greater recruitment intensity were observed. The most intense period occurred from March to July 2014 (values between 3 and 46%) and the less intense from October 2013 to January 2014 (values between 3 and 25%) (Figure 3 A). Juvenile abundance differed significantly among months (Kruskal-Wallis, $H = 20.43$; $p < 0.05$) (Figure 3 B). Both juveniles of *X. kroyeri* and *L. schmitti* showed higher abundances in shallow regions at 5 and 15 m depth (Figure 4 A). For *F. subtilis*, a different pattern was found, with higher abundances of juveniles at 15 and 30 m depth (Figure 4 A). Abundance of juvenile individuals was significantly different for the three species in relation to spatial distribution (Kruskal-Wallis, $p < 0.05$) (Figure 4 B).

Reproductive period and distribution of reproductive categories

Reproductive females (ED + DE) of *X. kroyeri* were found during all months. However, the frequency of reproductive females in relation to adult females showed a period of greater intensity from January to May 2014 (values between 33 and 39%) (Figure 5 A). The DE males of *X. kroyeri* were present all months, composing more than 50% in relation to the RU males (Figure 5 A). Abundance of these females was not significantly different between months (KruskalWallis, H = 15.94; p = 0.14) (Figure 5 B).

Reproductive females (ED + DE) of *F. subtilis* did not occur in December 2013 and January and March 2014. The higher reproductive intensity occurs from September to November 2013 (values between 7 and 77%) and from May to August 2014 (values between 6 and 18%) (Figure 5 A). The DE males of *F. subtilis* presented a proportion higher than 50% in relation to RU males in September and October 2013 and from May to August 2014 (Figure 5 A). The abundance of these females did not differ significantly between months (Kruskal-Wallis, H = 16.47; p = 0.12) (Figure 5 B). The reproductive females (ED + DE) of *L. schmitti* were absent only in April and July 2014. Nevertheless, two periods of higher frequency of reproductive females were identified; the main one from September to November 2013 (values between 18 and 40%) and one with lower intensity from January to May 2014 (values between 8 and 12%) (Figure 5 A).

The DE males of *L. schmitti* only exceeded the 50% total of adult RU males caught in September 2013,

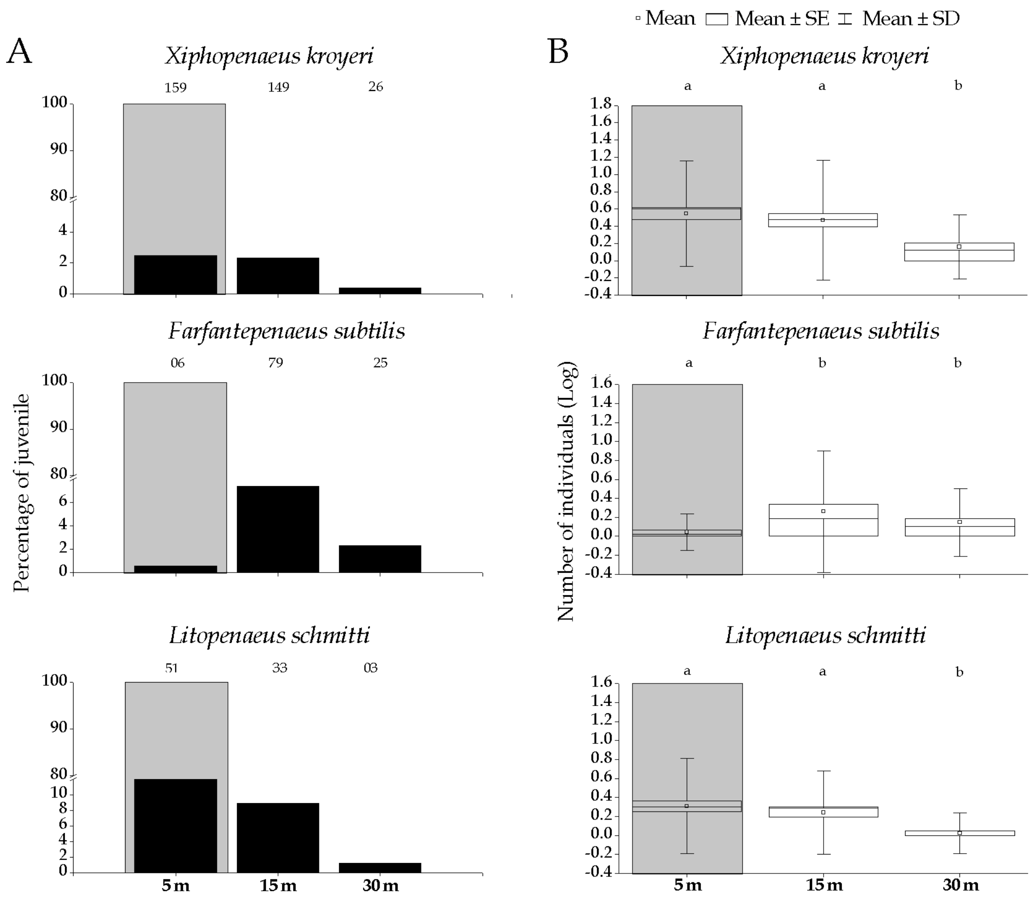

Figure 4. Percentages of juveniles. Abundance of individuals sampled in each month is represented at the top of the bars. B. Spatial distribution of juveniles. Distinct letters above boxes indicate significant statistical differences (Dunn's test α = 0.05). The highlighted bars in gray indicate the depths included in the fishing exclusion area stipulated by the normative instruction MMA n° 14, of October 14th 2004).

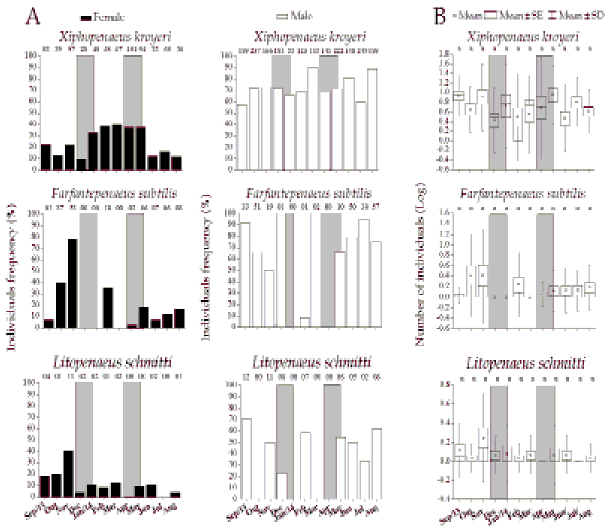

Figure 5. A. Percentages of reproductive individuals. Abundance of individuals sampled in each month is represented at the top of the bars. B. Temporal distribution of reproductive individuals. Distinct letters above boxes indicate significant statistical differences (Dunn's test α = 0.05). The highlighted bars in gray indicate the months in the current closed season (normative instructions MMA n° 14, of October 14th 2004).

February, May, and August 2014 (Figure 5 A). The abundance of these females did not differ among the sample months (Kruskal-Wallis, $H = 12.51$; $p = 0.32$) (Figure 5 B).

Reproductive males and females of *X. kroyeri* occurred more frequently at 5 and 15 m (Figure 6 A). For *F. subtilis*, higher frequency of reproductive individuals was observed at 30 m, and we found no females with developed gonads at 5 m (Figure 6 A). Reproductive males of *L. schmitti* occurred more frequently at 30 m, while females demonstrated higher frequency at 15 m (Figure 6 A). Regarding depth, the abundance of reproductive categories differed between the depths for *X. kroyeri* (Kruskal-Wallis, $H = 12.37$; $p<0.01$) and *F. subtilis* (Kruskal-Wallis, $H= 29.13$; $p < 0.01$) (Figure 6 B).

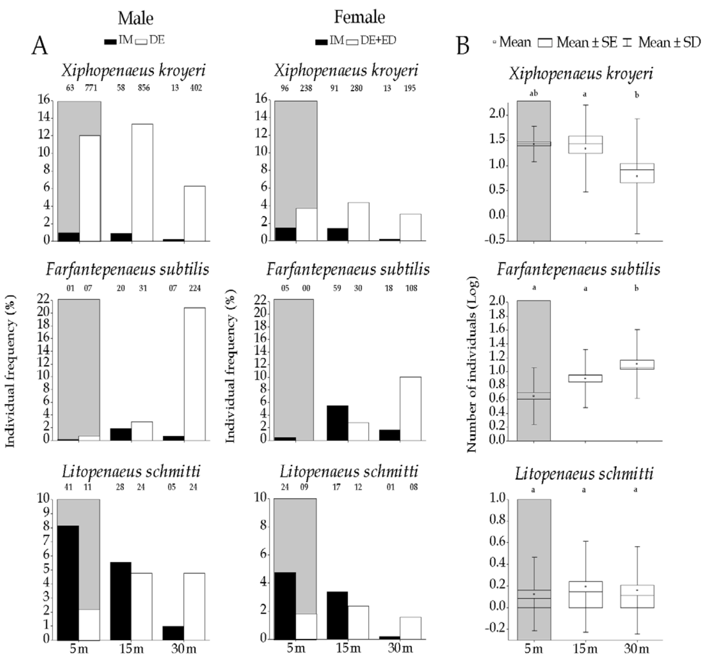

Figure 6. Percentage of reproductive individuals. The total number reproductive individuals sampled in each month is represented at the top of the bar (ED + DE = developed gonads + gonads in development; IM = immature gonads). B. Spatial distribution of reproductive individuals. Distinct letters above boxes indicate significant statistical differences (Dunn's test α = 0.05). The highlighted bars in gray indicate the depths included in the fishing exclusion area stipulated by the normative instructions MMA n° 14, of October 14th 2004.

The specie *L. schmitti* did not demonstrate differences in reproductive individual distribution among depths (Kruskal-Wallis, H = 1.38; p = 0.50); nevertheless, reproductive males demonstrated a positive correlation with depth (Figure 6 B).

DISCUSSION

The study area is characterized by low variation of hydrological factors, probably due to the Brazil Current and the influence of coastal and tropical water masses, which carry warm and oligotrophic waters (MACEDO *et al.*, 2004). In relation to sediment, the predominance of fine sand is related to the large sediment contribution from estuaries, also contributing to the high percentages of organic matter found during the study period (MILLIMAN and MEADE, 1983). Besides that, the coarse sand found at 30 m was associated to biogenic substrate, which may explain the high values of organic matter at this depth. These variations in environmental factors can reflect variations at the reproductive period, once it can ensure the reproductive success under favorable environmental conditions (Sastry, 1983).

At the studied area, the principal peaks of recruitment of *F. subtilis* and *L. schmitti* occurred in January and May and in March and July. For *X. kroyeri*, highest recruitment intensity occurred between September and December. These differences may be a consequence from different life cycles, since the different cycles and occupation of habitat by the development phases in Penaeidae may be responsible for a complex seasonal and spatial pattern of the life history of these shrimps (DALL *et al.*, 1990; BARBIERI *et al.*, 2015).

For all three species, we found the highest frequencies of juveniles in the shallow areas, 5 m for *X. kroyeri* and *L. schmitti* and 15 m in the case of *F. subtilis*. The species *F. subtilis* and *L. schmitti* are included in the life cycle type 2, in which the larvae migrate to estuaries and return to the marine environment once they reach the final juvenile phase (DALL *et al.*, 1990; COELHO and SANTOS, 1993; FERREIRA, 2013; BARBIERI *et al.*, 2014; BOCHINI *et al.*, 2014). Thus, we suppose that the great quantity of juveniles sampled at 5 and 15 m, in comparison to 30 m, was due to the migratory behavior of these species. Juvenile and adult individuals of *X. kroyeri* are expected to be found in the same area simultaneously, since juveniles of this species do not use estuaries (VALENTINI *et al.*, 1991; BRAGA, 2000; BRANCO, 2005; HECKLER *et al.*, 2013).

The reproductive periodicity was based mainly on females, once the frequency of reproductive males was constant throughout the year. The greatest reproductive intensities were registered from January to May for *X. kroyeri* and from September to November for *F. subtilis*, which is in agreement with the results from previous studies on these species in other regions of Brazil (SANTOS and IVO, 2000; SANTOS *et al.*, 2001; CASTRO *et al.*, 2005, SANTOS and FREITAS, 2006; ALMEIDA *et al.*, 2012; HECKLER *et al.*, 2013; CASTILHO *et al.*, 2015). For *L. schmitti*, due the low number of reproductive females (≤ 11) and developed males (≤ 12) during all studied months, our results should be considered with caution.

Greater abundance of reproductive females of *F. subtilis* at 30 m depth corroborates with its proposed life cycle, in which adult individuals migrate to deeper regions for copulation and spawning (BRAGA, 2000). For *L. schmitti*, spawning occurs in shallow marine waters (SANTOS, 2010b). For *X. kroyeri*, there is no population stratification and all life phases occur in a common area (VIEIRA, 1947; SANTOS *et al.*, 2006; SANTOS *et al.*, 2013). Therefore, the major number of reproductive females in shallow areas may be influenced by the fact that this species normally inhabits shallow regions.

The presence of juveniles and reproductive females of the three species during the entire study period demonstrates continuous reproduction. This pattern can be expected for penaeid shrimps from tropical and subtropical regions, with reproductive periods and juvenile recruitment throughout the year, although with peaks (DALL *et al.*, 1990). We observed one peak of reproductive and recruitment intensity for *X. kroyeri* and *F. subtilis* and two peaks for *L. schmitti*.

We also contrasted the obtained results with the current management plan. The first closed season from April 1st to May 15th includes the period of higher intensity of juveniles from *F. subtilis* (between January and May) and *L. schmitti* (between March and July), and also favor partially the principal peak of reproductive activities in females of *X. kroyeri* (between January and May). The second closed season from December 1st to January 15th protects part of the recruitment peak of *F. subtilis* (between January and May) and the second peak of *L. schmitti* (between October and January), also partially protecting the principal peak of *X. kroyeri* occurring from September to December, albeit with higher percentages in September and October. According to these results, the closed season does not completely benefit neither the juveniles of *X. kroyeri* nor the reproductive females of *F. subtilis* and *L. schmitti*, which have their main reproduction peaks between October and November.

Regarding the fishing exclusion area delimited by IBAMA ("Instituto Brasileiro do Meio-Ambiente e dos Recursos Naturais Renováveis"), it is important to note that the majority of *X. kroyeri* and *L. schmitti* juveniles and reproductive females were found inside the two nautical miles area. Nevertheless, for *F. subtilis*, the juveniles were more abundant at 15 m depth, which is at the threshold of the protected area while their reproductive females were more abundant at 30 m depth, outside the protected area. This demonstrates that the fishing exclusion area is not effective in the protection of the critical phases of *F. subtilis* life cycle.

CONCLUSIONS

Based on the obtained data, the species do not present synchronous recruitment and reproductive period, thus, should be treated independently in a possible adequacy of the management plan, guaranteeing a greater efficiency in the conservation of the natural stocks. Nevertheless, the protection area of two nautical miles from the coast, although aimed at the protection of sea turtles, plays an important role in the protection of the shrimp species *X. kroyeri* and *L. schmitti*, supporting management and conservation of these natural stocks. Hereby, *L. schmitti* is most protected from commercial fishery, as its recruitment period matches with the closed season and large amounts of reproductive females and juveniles are inside the fishery exclusion.

At the same time, there is a major commercial fishery impact on the pink shrimp *F. subtilis*, since the juveniles of this species are distributed in higher quantities outside the fishing exclusion area stipulated by the normative instruction n° 14, October 14th 2004. Besides that, the reproductive period of this species does apparently not coincide with the two closed seasons. It is therefore suggested that greater attention should be paid to the conservation of *F. subtilis*. In this case, a change on the two 45 days closed seasons to only one 90 days closed season, from March to May, could be more appropriate, as it would more efficiently protect pink shrimp recruitment.

Studies evaluating the reproductive aspects and life cycles of marine shrimp species commercially exploited in Northeast Brazil are still scarce. Therefore, the data presented in this study are of utmost importance since they provide significant information for evaluation of the current management plan efficiency, suggesting possible adjustments. However, continuous reproduction and recruitment evaluation is necessary, especially in terms of expanding the sampling period and increasing the spatial scale, in order to enable more precise analyses in the future.

ACKNOWLEDGMENT

The authors would like to thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for financial support, Universal – MCTI/CNPQ N° 14/2012 proc. #482802/2012-0. We are also thankful to IBAMA for the sample/transportation liberation of wild fauna *in situ* to scientific goals Proc# nº 02070.001067/2013-96, according to the state and federal regulatory rules SISBIO. In addition, we thank CAPES for providing scholarships to RCS and SLRS.

REFERENCES

ALBERTONI, E.F.; PALMA-SILVA, C.; 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(3): 409-41.

ALMEIDA, A.C.; BAEZA, J.A.; FRANSOZO, V.; CASTILHO, A.L. and FRANSOZO, A. 2012 Reproductive biology and recruitment of *Xiphopenaeus kroyeri* in a marine protected area in the Western Atlantic: implications for resource management. *Aquatic Biology, 17(1)*: 57-69.

BARBIERI, E.; MEDEIROS, A.M.Z.; HENRIQUES, M. B. 2015 Oxygen consumption and ammonia excretion of juvenile pink shrimp (*Pharfantepenaeus paulenis*) in culture: temperature effects. *Marine and Freshwater Behaviour and Physiology*, *49*(1): 9-25.

BARBIERI, E.; BONDIOLI, A.C.V.; MELO, C.B.; HENRIQUES, M.B. 2014. Nitrite toxicity to *Litopenaeus* *schmitti* (Burkenroad, 1936, Crustacea) at different salinity levels. *Aquaculture Research*, *47*(4):1260-1268

BAUER, R.T.; RIVERA-VEGA, L.W. 1992 Pattern of reproduction and recruitment in two sicyiniid shrimp species (Decapoda: Peneaoidea) from a tropical seagrass habitat. *Journal of Experimental Marine Biology and Ecology*, *161*(2):223-240.

BAUER, R.T.; LIN, J. 1994 Temporal patterns of reproduction and recruitment in populations of the penaeid shrimps *Trachypenaeus similis* (Smith) and *T. constrictus* (Stimpson) (Crustacea: Decapoda) from the north-central Gulf of Mexico. *Journal or Experimental Marine Biology and Ecology*, *182*(2): 205-222.

BOCHINI, G.L.; FRANSZO, A.; CASTILHO, A.L.; HIROSE, G.L.; COSTA, R.C. 2014 Temporal and spatial distribution of the commercial shrimp *Litopenaeus schmitti* (Dendrobranchiata: Penaeidae) in the south-eastern Brazilian coast. *Journal of the Marine Biological Association of the United Kingdom*, *94*(5): 1001–1008.

BOSCHI, E.E.; SCELZO, M.A. 1977 Desarrollo larval y cultivo del camarón commercial de argentina *Artemesia longinaris* Bate (Crustacea, Decapoda, Penaeidae). *Food and Agriculture Organization of the United States.*

BRAGA, M.S.C. 2000 *A pesca de arrasto de camarões na zona costeira do Município de Fortaleza, estado do Ceará*. Ceará. 152f. (Dissertação de Mestrado. Universidade Federal do Ceará, UFC). Disponível em: <http://www.repositorio.ufc.br/handle/riufc/4914> Acesso em: 03 jun. 2016.

BRANCO, J.O. 2005 Biologia e pesca do camarão sete-barbas *Xiphopenaeus kroyeri* (Heller) (Crustacea, Penaeidae), na Armação do Itapocoroy, Penha, Santa Catarina, Brasil. *Revista Brasileira de Zoologia*, *22*(4): 1050-1062.

BRASIL, 2004a INSTRUÇÃO NORMATIVA n° 14, de 14 de outubro de 2004. Regulamentação da pesca de camarões nos Estados de Alagoas, Sergipe e Bahia, Nordeste, Brasil. *Diário Oficial da República Federativa do Brasil*, 15 de outubro de 2004, Seção 1, p. 103-104.

BRASIL, 2004b INSTRUÇÃO NORMATIVA n° 05, de 21 de maio de 2004. Lista de Espécies de Invertebrados Aquáticos e Peixes Ameaçados de Extinção. *Diário Oficial da República Federativa do Brasil*, 28 de maio de 2004, Seção 1, p. 136-142.

CARVALHO, M.E.S.; FONTES, A.L. 2007 A Carcinocultura no Espaço Litorâneo Sergipano. *Revista da Fapese, 3*(1): 87-112.

CASTILHO, A.L.; GAVIO, M.A.; COSTA, R.C.; BOSCHI, E.E.; BAUER, R.T.; FRANSOZO, A. 2007 Latitudinal variation in population structure and reproductive pattern of the endemic South American shrimp *Artemesia longinaris* (Decapoda: Penaeoidea). *Journal of Crustacean Biology*, *27*(4): 548–552.

CASTILHO, A.L.; BAUER, R.T.; FREIRE, F.A.M.; FRANSOZO, V.; COSTA, R.C.; GRABOWSKI, R.C.; FRANSOZO, A. 2015 Lifespan and reproductive dynamics of commercially important sea bob shrimp *Xiphopenaeus kroyeri* (Crustacea: Penaeidae): synthesis of a 5-year study. *Journal of Crustacean Biology*, *35*(1): 1-11.

CASTRO, R.H.; COSTA, R.C.; FRANSOZO, A.; MANTELATTO, F.L.M. 2005 Population structure of the seabob shrimp *Xiphopenaeus kroyeri* (Heller, 1862) (Crustacea: Penaeoidea) in the littoral of São Paulo, Brazil. *Scientia Marina*, *69*(1): 105-112.

COELHO, P.A.; SANTOS, M.C.F. 1993 Época de reprodução do camarão sete-barbas *Xiphopenaeus kroyeri* (Heller, 1862) (Crustacea, Decapoda, Penaeidae) na região de Tamandaré, PE. *Boletim Técnico-Científico CEPENE*, *1*(1): 171-186.

COSTA, R.C.; FRANSOZO, A.; MELO, G.A. S.; 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)*. [online] URL: <http://www.biotaneotropica.org.br/v3n1/pt/> Acesso em: 25 mai. 2016

COSTA, R.C.; FRANSOZO, A. 2004 Reproductive biology of the shrimp *Rimapenaeus constrictus* (Decapoda, Penaeidae) in the Ubatuba Region of Brazil. *Journal of Crustacean Biology*, *24*(2):274-281.

COSTA, R.C.; FRANSOZO, A.; FREIRE, F.A.; CASTILHO, A.L. 2007 Abundance and Ecological Distribution of the "Sete-Barbas" Shrimp *Xiphopenaeus kroyeri* (Heller, 1862) (Decapoda: Penaeoidea) in Three Bays of the Ubatuba Region, Southeastern Brazil. *Gulf and Caribbean Research*, *19*(1): 33-41.

DALL, W.; HILL, B.J.; ROTHILSBERG, P.C.; STAPLES D.J. 1990 The biology of the Penaeidae. In: BLAXTER, J.H.S.; SOUTHWARD, A.J. *Advances in Marine Biology*. San Diego, Academic Press, 489p.

DELEO, F.C.; PIRES-VANIN, A.M.S. 2006 Benthic megafauna communities under the influence of the South Atlantic Water intrusion onto the Brazilian SE shelf: A comparison between an upwelling and a non-upwelling ecosystem. *Journal of Marine Systems*, *60*(3): 268-284.

DIAS-NETO, J (org.). 2011 *Proposta de Plano Nacional de Gestão para o uso sustentável do Caranguejo-Uçá,* *do Guaiamum e do Siri-azul.* IBAMA. Brasília: Série Plano de Gestão Recursos Pesqueiros, 4: 156 p.

EUTRÓPIO, F.J.; MARIANTE, F.L.F.; JUNIOR, P.D.F.; KROHLING, W. 2013 Population parameters of the shrimp *Xiphopenaeus kroyeri* (Heller, 1862) (Crustacea, Penaeidae), caught by artisanal fisheries in Anchieta, Espírito Santo State. *Acta Scientiarum. Biological Sciences*, *35*(2): 141-147.

FERREIRA, V. 2013 *Biodiversidade e variação espaço-temporal da abundância das populações de camarões e estrutura populacional de* ***Farfantepenaeus subtilis*** *(Pérez-Farfante, 1967) (Penaeidae) em um estuário do litoral amazônico brasileiro.* Pará. 99f. (Dissertação de mestrado. Universidade Federal do Pará, UFPA). Disponível em: <http://www.repositorio.ufpa.br/jspui/handle/2011/6000> Acesso em: 30 abr. 2016.

HECKLER, G.S.; SIMÕES, S.M.; LOPES, M.; ZARA, F.J. and COSTA, R.C. 2013 Biologia populacional e reprodutiva do camarão sete-barbas na baía de Santos, São Paulo. *Boletim do Instituto de Pesca*, *39*(3): 283-297.

LEMOS-JUNIOR, I.C.; MACHADO, A.J.; ANDRADE, E.J.; VIEIRA, F.S.; GUIMARÃES, C.R.P. 2014 Macroforaminíferos da plataforma continental de Sergipe, Brasil. *Scientia Plena, 10*(1): 1-11.

MACEDO, S.J.; MUNIZ, K.; MONTES, M.J.F. 2004 Hidrologia da região costeira e plataforma continental do estado de Pernambuco. In: ESQUINAZI-LEÇA, E. NEUMANN-LEITÃO, S. COSTA, M.F. *Oceanografia: um cenário tropical.* Recife, Bargaço. p. 255-286.

MANTELATTO, F.L.M.; FRANSOZO, A. 1999 Characterization of the physical and chemical parameters of Ubatuba Bay, northern coast of São Paulo State, Brazil. *Revista Brasileira de Biologia*, *59*(1): 23-31.

MILLIMAN, J.D.; MEADE, R.H. 1983 World-wide delivery of river sediment to the oceans. *Journal of Geology*, *91*(1): 1-21.

NAKAGAKI, J.M.; NEGREIROS-FRANSOZO, M.L. 1998 Population biology of *Xiphopenaeus kroyeri* (Heller, 1862) (Decapoda: Penaeidae) from Ubatuba Bay, São Paulo, Brazil. *Journal of. Shellfish Research, 17*(4): 931-935.

PAULY, D.; CHRISTENSEN, V.; GUÉNETTE, S.; PITCHER, T.J.; SUMAILA, U.R.; WALTERS, C.J.; WATSON, R.; ZELLER, D. 2002 Towards sustainability in world fisheries. *Nature, 418*(6898): 689–695.

PEREIRA, S.M.B.; TORRES, J.; GESTINARI, L.M.S. 2014 Composition and Distribution of Deep Water Macroalgae Species from the Continental Shelf of Sergipe State, Brazil. *Phytotaxa, 190*(1): 250-267.

SANTOS, M.C.F.; IVO, C.T.C. 2000 Pesca, biologia e dinâmica populacional do camarão sete-barbas *Xiphopenaeus kroyeri* (Heller, 1862) (Crustacea: Decapoda: Penaeidae), capturado em frente ao município de Caravelas (Bahia-Brasil). *Boletim Técnico-Científico CEPENE*, *8*(1): 131-164.

SANTOS, M.C.F.; RAMOS, I.C.; FREITAS, A.E.T.S. 2001 Análise de produção e recrutamento do camarão sete-barbas, *Xiphopenaeus kroyeri* (Heller, 1862) (Crustacea: Decapoda: Penaeidae), no litoral do estado de Sergipe – Brasil. *Boletim Técnico Científico da CEPENE*, *9*(1): 53-71.

SANTOS, M.C.F; SILVA, A.C.C.D.; FREITAS, A.E.T.S.; SOUSA, G.S. 2007 Prospecção de camarões marinhos (Crustacea, Decapoda, Penaeidae) na plataforma continental do estado de Sergipe, Brasil. *Boletim Técnico Científico da CEPENE*, 15(2): 47-56.

SANTOS, M.C.F.; FREITAS, A.E.T.S. 2006 Caracterização biológica e pesqueira do camarão sete-barbas, *Xiphopenaeus kroyeri* (Heller, 1862) (Crustacea, Decapoda, Penaeidae), no pesqueiro Laminha, área de Proteção Ambiental de Piaçabuçu (Alagoas – Brasil). *Boletim Técnico Científico da CEPENE*, *14*(1): 71-91.

SANTOS, M.C.F.; COELHO, P.A.; PORTO. M.R. 2006 Sinopse das informações sobre a biologia e pesca do camarão sete-barbas, *Xiphopenaeus kroyeri* (Heller, 1962) (Decapoda, Penaeidae), no nordeste do Brasil. *Boletim Técnico Científico CEPENE*, *14*(1): 141-178.

SANTOS, M.C.F. 2010a Ordenamento da pesca de camarões no Nordeste do Brasil. *Boletim Técnico Científico CEPENE*, *18*(1): 91-98.

SANTOS, M.C.F. 2010b Informações biológicas e pesqueiras sobre o camarão branco *Litopenaeus schmitti* (Bukenroad, 1936) e o camarão rosa *Farfantepenaeus subtilis* (Pérez-Farfante, 1967) capturados no município de Coruripe (Alagoas-Brasil). *Boletim Técnico Científico CEPENE*, *18*(1): 17-29.

SANTOS, M.C.; BRANCO, J.O.; BARBIERI, E. 2013 Biologia e pesca do camarão sete-barbas nos estados nordestinos brasileiros onde não há regulamentação do período de defeso. *Boletim do Instituto de Pesca, 39*(3): 217-235.

SASTRY, A.N. 1983 Ecological aspects of reproduction. In: VERNBERG, F.J. and VERNBERG, W.B. *The Biology of Crustacea*. Academic Press, p. 179-270.

SILVA, A.C.C.D.; CASTILHOS, J.C.; SANTOS, E.A.P.; BRONDÍZIO L. S.; BUGONI, L. 2010 Efforts to reduce sea turtle bycatch in the shrimp fishery in Northeastern Brazil through a co-management process. *Ocean & Coastal Management*, *53*(9): 570-576.

SUGUIO, K. 1973 *Introdução à sedimentologia*. ed. Edgard Blucher, EDUSP, São Paulo. 317p.

THOMÉ-SOUZA, M.J.F.; DANTAS-JUNIOR, J.F.; SILVA, F.C.B.; FÉLIX, D.C.F.; SANTOS, J.C. 2012 *Estatística pesqueira da costa do Estado de Sergipe e extremo norte da Bahia 2010*. São Cristóvão: Editora UFS, 88p.

THOMÉ-SOUZA, M.J.F.; DEDA, M.S.; SANTOS, J.P.; CARVALHO, B.L.F.; ARAÚJO, M.L.G.; GARCIOV-FILHO, E.B.; FÉLIX, D.C.F.; SANTOS, J.C. 2013 *Estatística pesqueira da costa do Estado de Sergipe e extremo norte da Bahia 2011*. São Cristóvão: Editora UFS, 92p.

THOMÉ-SOUZA, M.J.F.; CARVALHO, B.L.F.; SILVA, C.O.; DEDA, M.S.; GARCIOV-FILHO, E.B.; FÉLIX, D.C.F.; SANTOS, J.C. 2014a *Estatística pesqueira da costa do Estado de Sergipe e extremo norte da Bahia 2012*. São Cristóvão: Editora UFS, 102p.

THOMÉ-SOUZA, M.J.F.; CARVALHO, B.L.F.; GARCIOV-FILHO, E.B.; SILVA, C.O.; DEDA, M.S.; FÉLIX, D.C.F.; SANTOS, J.C. 2014b *Estatística pesqueira da costa do Estado de Sergipe e extremo norte da Bahia 2013*. São Cristóvão: Editora UFS, 108p.

VALENTINI, H.; D' INCAO, F.; RODRIGUEZ, L.F.; REBELO NETO, J.E. & DOMITI L.G. 1991 Análise da pesca do camarão sete-barbas (*Xiphopenaeus kroyeri*) nas regiões sudeste e sul do Brasil. *Atlântica*, *13*(1): 171-178.

VASCONCELLOS, M.; DIEGUES, A.C.; SALLES, R.R. 2007 Limites e possibilidades na gestão da pesca artesanal costeira. In: COSTA A.L. *Nas redes da pesca artesanal*. PNUD/IBAMA, Brasília p. 15-83.

VIEIRA, B.B. 1947 Observação sobre a maturação de *Xiphopenaeus kroyeri* no litoral de São Paulo. *Boletim do Museu Nacional*, *Rio de Janeiro 74*(1): 1-22.

WENTWORTH, C.K. 1922 A scale of grade and class terms for clastic sediments. *The Journal of Geology*, *30*(5): 377-392.