Population dynamics of Atlantic seabob *Xiphopenaeus kroyeri* (Decapoda: Penaeidae) off the state of Sergipe, north-eastern Brazil

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The aim of this study was to analyse the population dynamics of Xiphopenaeus kroyeri *in Sergipe, Brazil. Four samples were collected monthly from shrimp trawlers based in the municipality of Pirambu from March 2015 to May 2016. Carapace length (CL), total length (TC), live weight (LW), sex and maturity stages were obtained for each specimen. A total of 13,035 individuals were analysed with an overall sex ratio of 1:1. However, this ratio favoured females in larger sizes, which reflects a reproductive strategy, as their larger size allows for larger gonads, higher fertility and production of more eggs. An inflexion point was observed in the relationship between total and carapace length, probably related to reproduction, as this occurred after first maturity. A reproduction peak was observed in August–September, which does not correspond to the closed season. The parameters estimated for a seasonally oscillating version of the von Bertalanffy growth function were $CL_\infty = 33$ mm and $K = 1.5$ year^{-1} for females, and $CL_\infty = 31$ mm and $K = 1.7$ year^{-1} for males ($C = 0.6$ and $WP = 0.8$ for both sexes). These estimates do not support the latitudinal rule in terms of larger sizes in higher latitudes, which may be associated to methodological differences, occurrence of more than one species along the South-western Atlantic coast, sampling bias, exploitation status and unbalanced availability of studies. The instantaneous total mortality rate was high and should be further investigated to allow for the definition of the exploitation status of seabobs in Sergipe.*

Keywords: growth, populational structure, reproduction, mortality

INTRODUCTION

Marine and estuarine fisheries are of major socioeconomic importance in Brazil, both in terms of food security and jobs, incomes and revenue generation (Haimovici *et al.*, 2014). Shrimp bottom trawlers are very efficient at catching shrimps, but they also damage aquatic habitats and ultimately threaten local biodiversity (Dias Neto, 2011).

Shrimp fisheries are carried out throughout the Brazilian coast (Dias Neto, 2011), targeting mainly species of the Penaeidae and Solenoceridae families (Haimovici *et al.*, 2014). In 2007, the latest year with catch statistics collected onsite, the catch of crustaceans in Brazilian marine waters exceeded 50,000 t, with over 35,000 t contributed by shrimps, of which 42% was Atlantic seabob *Xiphopenaeus kroyeri* (Heller, 1862) (IBAMA, 2007). In the state of Sergipe, Atlantic seabob (locally known as '*espigão*') is the top species with catches amounting to 944.8 t in 2013 (Thomé-Souza *et al.*, 2014).

Atlantic seabob occurs from the coast of North Carolina in the USA to Rio Grande do Sul in Brazil (D'Incao *et al.*, 2002).

Studies on its population structure and stock dynamics have been carried out throughout the Brazilian coast. More specifically, the reproductive period, size at first maturity, sex ratio, growth, distribution and abundance have been studied in the north (e.g. Carvalho *et al.*, 2015), north-east (Santos, 2000; Santos & Freitas, 2002; Couto *et al.*, 2013; Lopes *et al.*, 2014), south-east (e.g. Fernandes *et al.*, 2011; Heckler, 2014; Castilho *et al.*, 2015), and south of Brazil (e.g. Branco, 2005; Grabowski *et al.*, 2014; Natividade, 2014). In Sergipe, few studies were carried out for the Atlantic seabob (Santos *et al.*, 2001, 2007; Silva, 2016).

Fishery management measures currently in place for shrimp fisheries in Brazilian waters include minimum mesh size, closed inshore areas and closed seasons (Santos & Silva, 2008). In Sergipe, the closed season extends from 1 April to 15 May and from 1 December to 15 January (MMA, 2004). The effectiveness of the current management measures should be assessed, however, and changed when needed, to ensure that the removals from these stocks can be maintained in the long term and benefits accrued for both fishers and their communities (Dias Neto, 2011).

Due to the large socioeconomic importance of shrimp fisheries for the state of Sergipe, this study was carried out with the objective of analysing the population dynamics of the Atlantic seabob *X. kroyeri* off the coast of Sergipe to support management plans.

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MATERIALS AND METHODS

Sampling and processing

Samples were collected monthly from March 2015 to May 2016 from four different shrimp artisanal trawlers based in the municipality of Pirambu, in the state of Sergipe (Figure 1). All samples were obtained before any sorting by fishers and thus included both shrimps and by-catch. The samples were initially stored on ice and later kept frozen in the laboratory until processing. All shrimp species were identified according to Costa et al. (2003).

Each specimen of *X. kroyeri* was measured in terms of their total length (TL, mm) and carapace length (CL, mm) and weighed (live weight; LW, g) with a digital calliper (precision: 0.01 mm) and a scale (precision: 0.0001 g). All individuals were sexed based on the external morphology; the maturation stage of the gonads was classified according to Natividade (2006). Females were defined as immature (I), developing (II), mature (III) and spent (IV), and males as immature (non-linked petasma) and mature (linked petasma).

Statistical analyses

A chi-square test (χ^2) with the Yates correction for continuity was applied to test if the overall sex ratio differed from 1:1, as well as in each month and length class (Zar, 2010). The relationships between total length and carapace length were fitted using a linear model (TL = a + bCL) for males and females separately. An inflexion point (CL$_i$) was observed in these relationships and was estimated according to Sant'Ana et al. (2016). The relationships between live weight and carapace length were fitted with a linear version of the model LW = aCL^b for males and females separately. The hypotheses of isometry were tested for the length-length relationships ($b = 1$) and weight-length relationships ($b = 3$) using the t-test (Froese, 2006; Zar, 2010). All relationships estimated for females and males were compared using covariance analyses (Zar, 2010). For each test a significance level of 5% was used.

The reproduction period was defined based on the presence of mature and spent females (stages III and IV). The length at first maturity (CL50) was estimated fitting a logistic curve to the percentage of mature individuals (%mature) and

carapace length (CL) for females and males separately, using the following equation: %mature = 100/(1 + exp(a + b·CL)) (Sparre & Venema, 1998). Parameters 'a' and 'b' were estimated using a non-linear fitting method (SOLVER in Microsoft Excel).

The parameters of the von Bertalanffy growth curve were estimated for females and males, separately, using ELEFAN in R (Pauly & Greenberg, 2013). Asymptotic length (CL$_\infty$) was obtained using the Wetherall method (1986), which was later used for estimation of the growth parameter (K) using the K-scan routine available in ELEFAN in R. For males, this routine was not able to estimate a biologically reasonable K value. Therefore, the growth performance index ($\Phi' = \log K + 2\log CL_\infty$) was estimated for females, which was then used to estimate the K value for males. The growth parameters obtained in this study were compared with other studies using an auximetric plot. The winter point (WP) and the amplitude of seasonal oscillation (C) were estimated based on temperature data given in Silva (2016), which identified October as the coldest month (i.e. WP = 0.8) and a winter-summer bottom temperature range of 6°C which approximately corresponds to $C = 0.6$ (Pauly, 2010). The longevity (years) for females and males was calculated using the inverse of the von Bertalanffy equation (D'Incao & Fonseca, 1999). The total instantaneous mortality rate (Z) was derived from the Z/K estimate obtained from the Wetherall plot (1986) available in ELEFAN in R.

RESULTS

Sex ratio

A total of 13,035 specimens of *X. kroyeri* were collected and analysed: 6456 females and 6579 males. The overall sex ratio was not statistically different from 1:1 ($\chi^2 = 1.14$; $P = 0.2853$). However, there was a statistically significant predominance of females in August, October and January, and of males in September and November (Table 1). Females were more abundant among the larger sizes (Figure 2). The small
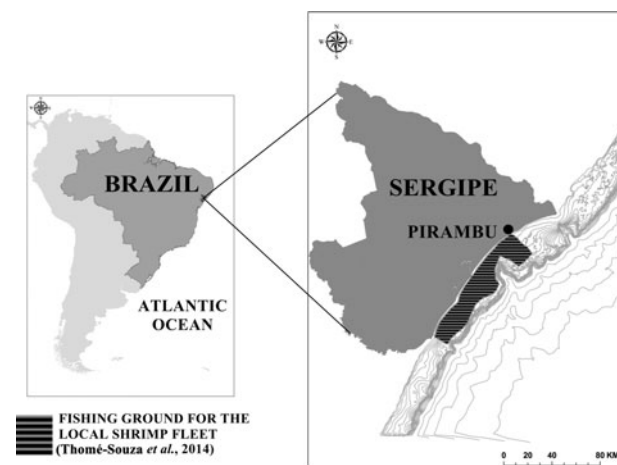
Table 1. Proportion of females and males of *Xiphopenaeus kroyeri* off the coast of Sergipe from March 2015 to May 2016.

Month/year	N females	N males	χ^2
Mar/15	230	205	1.32
Apr/15	Closed season	Closed season	Closed season
May/15	33	41	0.66
Jun/15	243	220	1.05
Jul/15	759	730	0.53
Aug/15	549	464	6.97*
Sept/15	813	1003	19.67*
Oct/15	700	602	7.23*
Nov/15	924	1201	35.85*
Dec/15	Closed season	Closed season	Closed season
Jan/16	433	369	4.95*
Feb/16	570	617	1.78
Mar/16	578	550	0.65
Apr/16	Closed season	Closed season	Closed season
May/16	624	577	1.76
Total	6456	6579	1.14

N, number of specimens.
*Statistically significant difference ($\chi^2 > 3.84$; $\alpha = 0.05$).

Fig. 1. Study area off the state of Sergipe (Brazil), indicating the location of the municipality of Pirambu and the fishing ground for the local shrimp fleet.
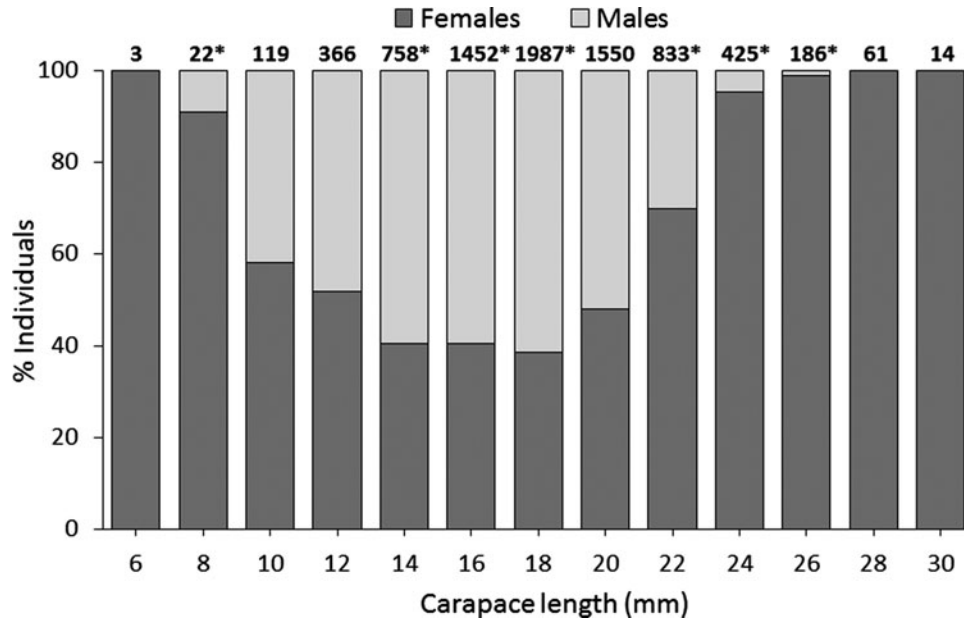
Fig. 2. Proportion of females and males of *Xiphopenaeus kroyeri* in Sergipe for each length class from March 2015 to May 2016. *Statistically significant difference ($\chi^2 > 3.84$; $\alpha = 0.05$).

number of individuals did not allow for a statistical comparison in some length classes.

Biometric analyses

The length of the females ranged from 5.9 to 30.2 mm CL and the length of the males was 7.3–25.1 mm CL. The mean carapace length for females (19.1 ± 4.0) was statistically larger than for males (17.4 ± 2.6) ($t = -21.55$; $P < 0.01$). The live weight of the females ranged from 0.1 to 12.8 g (4.0 ± 2.1) and that of males ranged from 0.3 to 8.9 g (3.3 ± 1.3). Similarly, the mean live weight for females was larger than for males ($t = 18.18$; $P < 0.01$). The relationships estimated between total and carapace length indicated the existence of an inflexion point (CL_i) at 17.0 mm for females and 16.0 mm for males (Figure 3). The slope of these relationships was higher for males both before and after the inflexion point. Moreover, the slope before this point was higher for both males and females.

The relationships between the live weight and carapace length for females and males were $LW = 0.0015CL^{2.654}$ ($r^2 = 0.953$) and $LW = 0.0010CL^{2.821}$ ($r^2 = 0.931$), respectively (Figure 4). Values of b for females and males were statistically different (ANCOVA: $F = 110.9$; $P < 0.01$), and both indicated a pattern of negative allometry: females ($t = 36.51$; $P < 0.05$) and males ($t = 14.35$; $P < 0.05$). Seasonal oscillations in the values of a and b were observed for both sexes (Figure 5).

Reproduction

The smallest mature female was 12.5 mm CL long and specimens larger than 17.5 mm CL were all mature or spent. The smallest mature male was 11.3 mm CL and all males larger than 15.5 mm CL were mature. The length at first maturity (CL_{50}) for females and males were 15.8 mm and 12.9 mm CL, respectively (Figure 6).
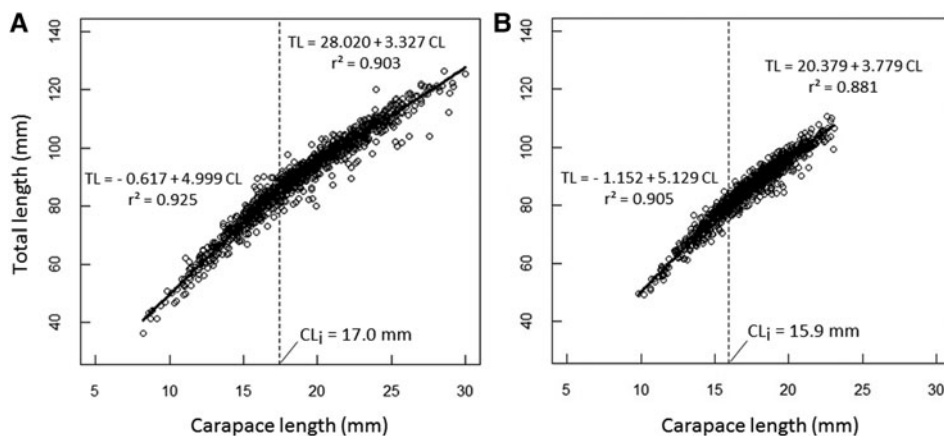

Fig. 3. Segmented regression between total length (TL) and carapace length (CL) for females (A) and males (B) of *Xiphopenaeus kroyeri* in Sergipe, indicating their respective inflexion points (CL_i).
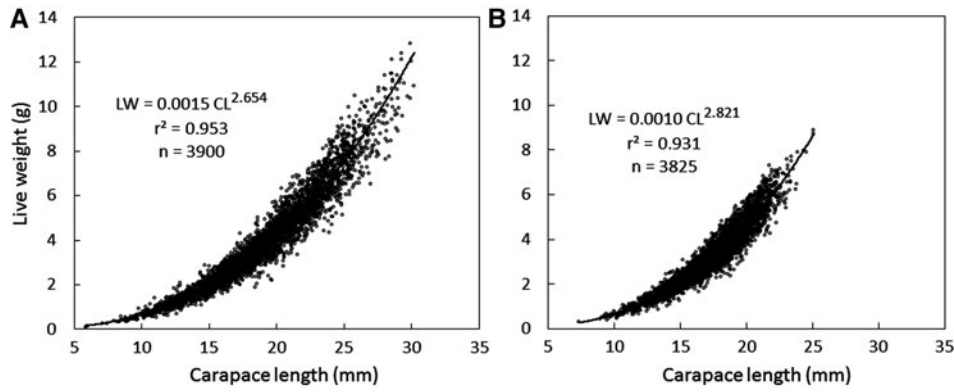
Fig. 4. Relationship between live weight (LW) and carapace length (CL) for females (A) and males (B) of *Xiphopenaeus kroyeri* in Sergipe from March 2015 to May 2016.

A continuous reproductive period was observed when analysing both females and males (Figure 7). However, a peak was evident in August–September, due to a large number of mature and spent females. During the closed season there was no sampling, and thus it was not possible to properly assess the occurrence of another reproductive period.

Growth and mortality

The asymptotic length (CL_∞) and growth parameter (K) for females were 33 mm CL (138 mm TL) and 1.5 year^{-1}, respectively, when C set at 0.6 and WP at 0.8 (Figure 8). For males, these values were 31 mm CL (137 mm TL) and 1.7 year^{-1}, respectively, for the same values of C and WP (Figure 8). The auximetric plot showed that our growth parameter estimates were well within the range in CL_∞ from

28.7–38.6 mm for females and 22.9–34.0 mm for males derived from several studies carried out for *X. kroyeri* along the Brazilian coast. This also applied for K, which has been reported to range from 0.29 to 3.65 year^{-1} for females and from 0.41 to 4.38 year^{-1} for males (Figure 9). The longevity estimated for females was 3.0 years and 2.7 years for males. The total instantaneous mortality rate (Z) calculated for females and males were 5.37 and 11.81 year^{-1}, respectively (Figure 10).

DISCUSSION

The sex ratio of *Xiphopenaeus kroyeri* has been studied throughout the Brazilian coast. Most of these studies indicated an equal proportion of males and females, but no latitudinal pattern was observed (Table 2). Even in the case of overall equal proportion, variation may occur among months and length classes. Other penaeids have a pattern that may vary from a 1:1 sex ratio to the predominance of females depending on the region: *Artemesia longinaris* (Costa *et al.*, 2010), *Litopenaeus schmitti* (Santos *et al.*, 2008), *Farfantepenaeus paulensis* (Branco & Verani, 1998), *F. brasilensis* and *Rimapenaeus constrictus* (Wolf, 2014). Several factors may influence the sex ratio of crustaceans, such as different migration pattern, growth and mortality rates, and longevity (Wenner, 1972). Length-associated sexual dimorphism is common in *X. kroyeri*, with females reaching larger size (Branco, 2005; Santos *et al.*, 2013; Lopes *et al.*, 2014;
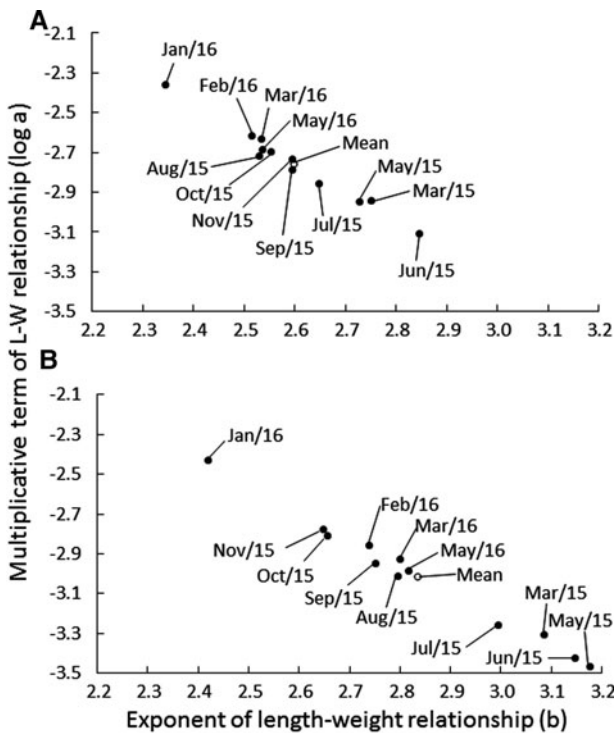

Fig. 5. Parameters *a* and *b* from the weight-length relationships estimated for each month for females (A) and males (B) of *Xiphopenaeus kroyeri* in Sergipe.
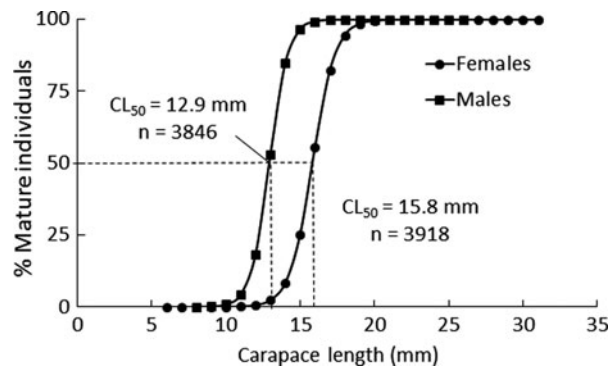

Fig. 6. Size at first maturity (CL_{50}) for females and males of *Xiphopenaeus kroyeri* in Sergipe from March 2015 to May 2016.
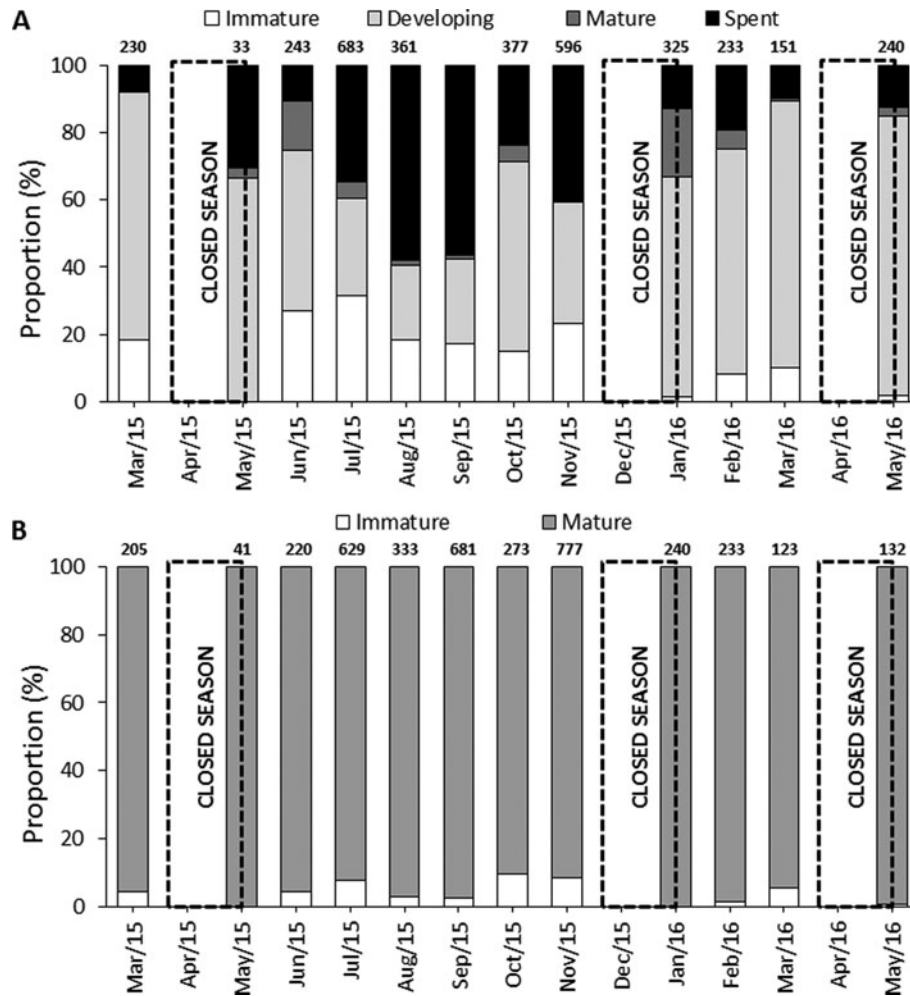
Fig. 7. Stages of gonadal maturation by month for females (A) and males (B) of *Xiphopenaeus kroyeri* in Sergipe from March 2015 to May 2016.

Castilho *et al.*, 2015). Other penaeids follow the same pattern: *Farfantepenaeus subtilis* (Silva, 2016), *F. brasiliensis* and *F. paulensis* (Leite Jr & Petrere Jr, 2006), and *Artemesia longinaris* (Sancinetti *et al.*, 2015). This reflects a reproductive strategy, as larger size for females allows for larger gonads, higher fertility and production of more eggs (Gab-Alla *et al.*, 1990).

The relationships between total length and carapace length for both sexes presented an inflexion point. For females, the inflexion occurred very close to the size at first maturity. The slope *b* estimated for males was higher than for females both before and after the inflexion point (CL$_i$). Several authors found the same pattern of higher slope for males in other areas (Ivo & Santos, 1999; Natividade, 2006; Martins *et al.*, 2013). This change in slope may be associated with the length at first maturity for both sexes, as it is observed after the first maturity. For females, this change occurs right after they mature for the first time (CL50 = 15.8 mm and CL$_i$ = 17.0 mm), as they spend more energy on the development of their gonads than males (Dall *et al.*, 1990). Another factor that can explain the higher slope before the inflexion point in both sexes is the high growth rate of juveniles in relation to adults (Dall *et al.*, 1990; Ocasio-Torres *et al.*, 2014).

The estimated weight-length relationship is characteristic of a negative allometric growth (*b* < 3). Several studies confirmed this pattern for *X. kroyeri* (Table 3). However, it is

worth pointing out that changes in *b* occur throughout the year, reaching values higher than 3 in March–July 2015 for males (even though this changed between years). This can be explained in part by environmental conditions that change over time (Castilho *et al.*, 2008; Natividade, 2014). Indeed, a 6°C temperature range for Sergipe (Silva, 2016) may be enough to result in changes in *b*. Unfortunately, no temperature data were collected in this study to assess the impact of this factor in the changes observed here from 2015 to 2016.

The length at first maturity for females (CL$_{50}$ = 15.8 mm) was higher than for males of *X. kroyeri* (CL$_{50}$ = 12.9 mm) in Sergipe. Similar results were found for the same species in other states and also for other penaeids: *Artemesia longinaris* (Costa *et al.*, 2010), *Rimapenaeus constrictus* (Costa & Fransozo, 2004) and *Farfantepenaeus subtilis* (Silva, 2016). The length at first maturity for *X. kroyeri* does not follow the latitudinal pattern described by Hines (1989) (Table 4). Other factors such as exploitation rates may have contributed to this non-compliance (King, 2007). For instance, Couto *et al.* (2013) estimated lower length at first maturity for *X. kroyeri* in exploited areas off the coast of Bahia in relation to marine protected areas (i.e. no-take zones). This would also be reflected in the near constancy of the CL$_{50}$/CL$_\infty$ ratio within the same taxonomic group as highlighted by Longhurst & Pauly (2007). Available data for *X. kroyeri* indicated that the CL$_{50}$/
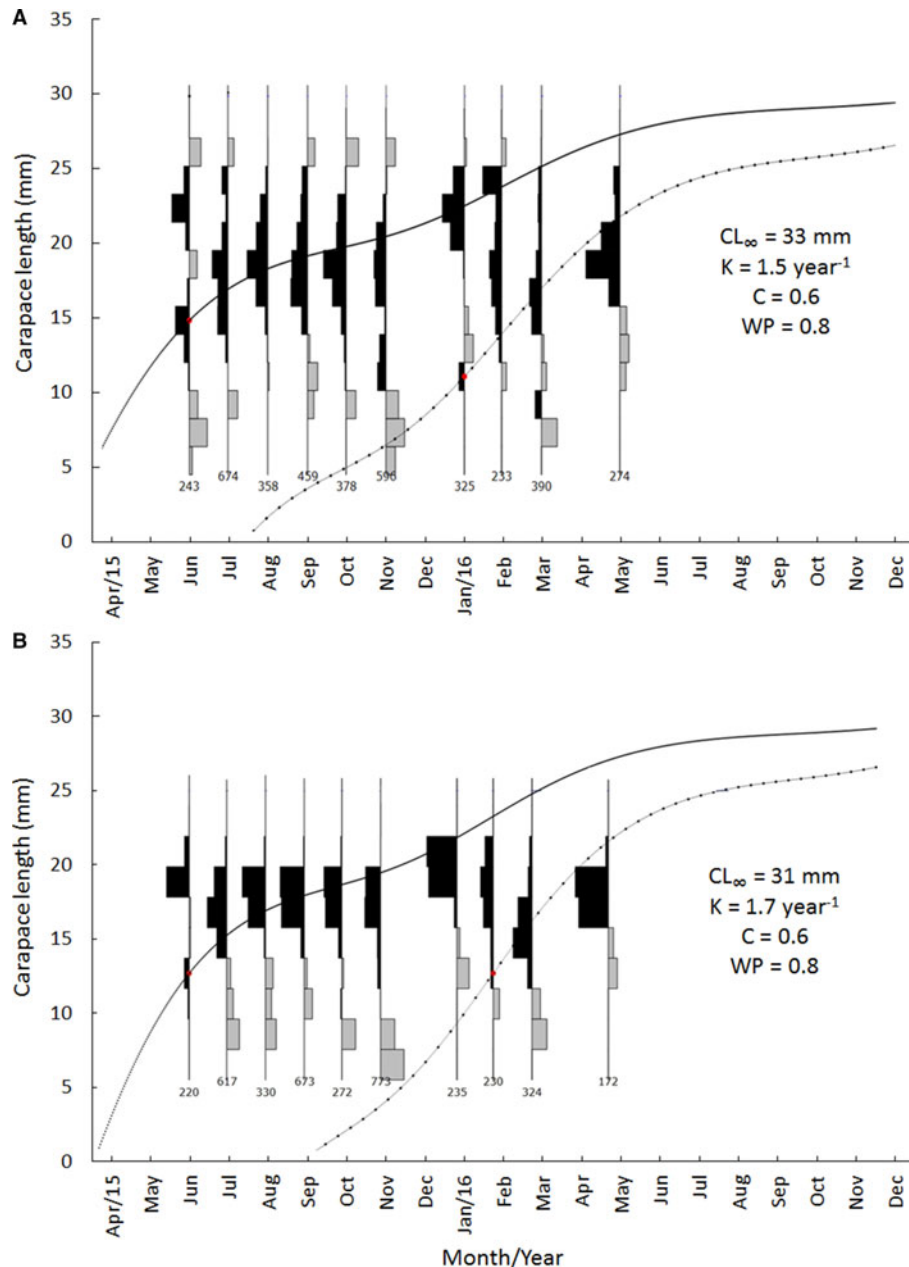
Fig. 8. Length frequency distribution and von Bertalanffy growth curve with seasonal oscillation for females (A) and males (B) of *Xiphopenaeus kroyeri* in Sergipe. CL_∞ = asymptotic carapace length, K = growth parameter, C = amplitude of seasonal oscillation, and WP = winter point.

CL_∞ ranged from 0.4 to 0.7, with an average of 0.5 for both sexes. Sergipe was in the lowest end (0.4 for both sexes). However, this ratio was different and even inverse in some studies: 0.71 and 0.45 (Fernandes *et al.*, 2011) for females and males, respectively, and 0.49 and 0.60 (Santos, 2014).

The reproductive period was continuous due to the presence of females in stages III (mature) and IV (spent) throughout the year. However, a reproductive peak was observed in August–September. According to Longhurst & Pauly (2007), tropical species have a longer breeding season, but always with peaks in certain periods, which is also generally expected for tropical penaeids (Dall *et al.*, 1990) and was found here for *X. kroyeri*. Indeed, the growth curves for both females and males of *X. kroyeri* could be traced back to the same period, suggesting that this cohort may have been

hatched in August–September. By December, when the fishing season is closed, both females and males are less than 10 mm CL, which is smaller than the size at first maturity for both sexes. Therefore, this second closing season would be protecting new recruits. Other studies found similar reproductive periods: in Piauí (Santos & Coelho, 1996), Sergipe (Santos & Coelho, 1998) and Rio de Janeiro (Oliveira, 2015). The reproductive peak for *X. kroyeri* may vary over time in the same region (Guimarães, 2009; Castilho *et al.*, 2015). However, overall reproductive peaks are observed when temperature is higher, which directly influences the maturation of gametes and spawning (Bauer, 1992). The highest bottom temperature in Sergipe was reported in May (Silva, 2016). Unfortunately, April–May corresponds to the closed season in the region and no sample was collected in
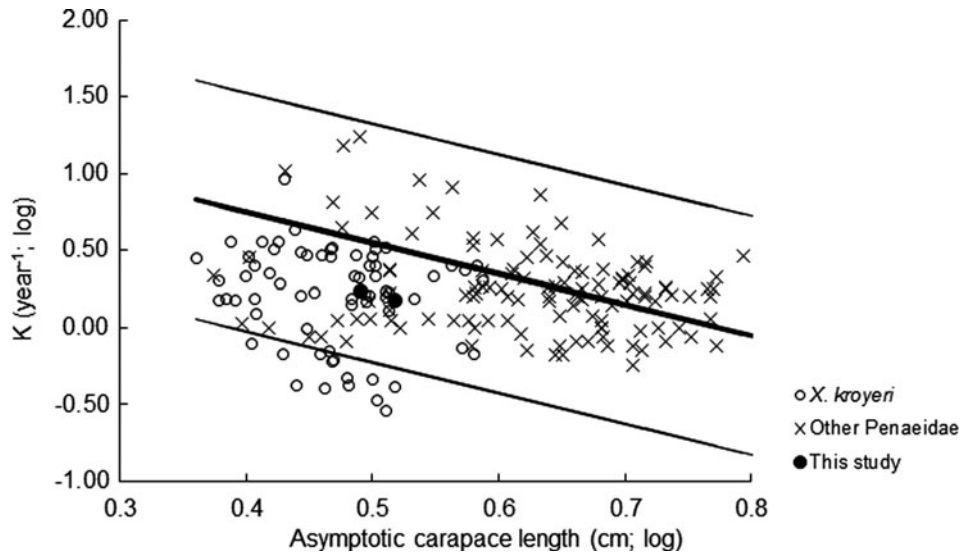
Fig. 9. Parameters of the von Bertalanffy growth curve (K and CL_∞) estimated for females and males of *Xiphopenaeus kroyeri* based on the compilation of the results of several studies carried out along the Brazilian coast, including this study, and of other Penaeidae around the globe. The lines represent a slope of 2 for Φ' and the lower and upper limits corresponding to a 50% change in the slope value.
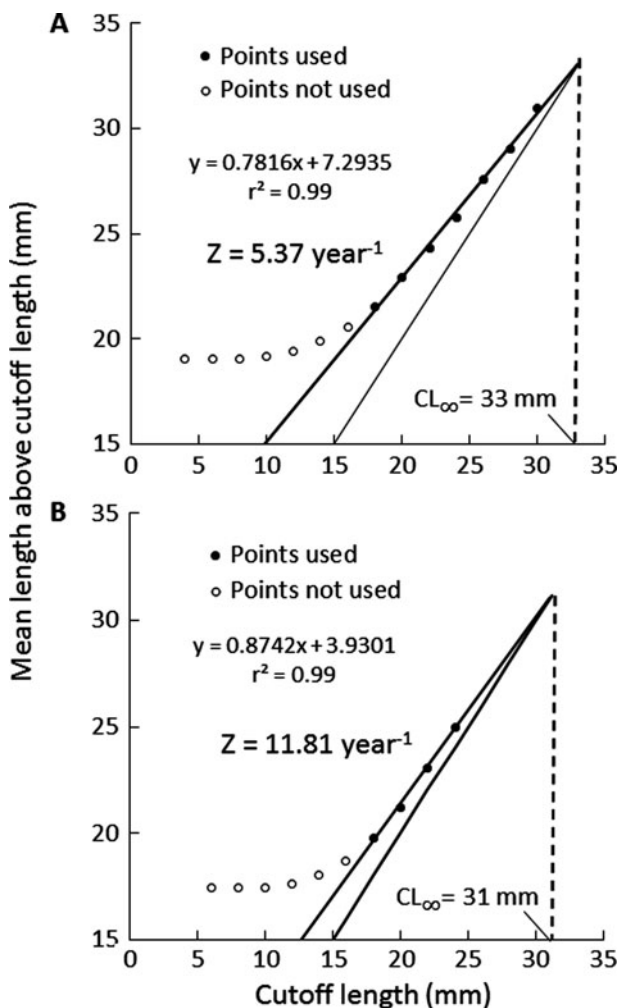

Fig. 10. Total instantaneous mortality rate (Z) estimated by the model of Wetherall (1986) for females (A) and males (B) of *Xiphopenaeus kroyeri* in Sergipe from March 2015 to May 2016. CL_∞ = asymptotic carapace length.

April or beginning of May. But here again, a second pair of growth curves could be traced back to April–May, suggesting that this may indeed correspond to the other reproductive peak observed for *X. kroyeri* off Sergipe, which is currently protected under the current management measure.

Females presented lower growth parameter (K) but reached larger sizes (CL_∞), a pattern general in penaeids (Dall *et al.*, 1990). Other authors found similar results for *X. kroyeri* (e.g. Branco, 2005; Freire, 2005; Grabowski *et al.*, 2014). Most of von Bertalanffy growth parameters estimated for *X. kroyeri* used FiSAT or PeakFit. Freire (2005) highlighted that the ELEFAN routine available in FiSAT usually underestimates the asymptotic length due to the exclusion of larger length classes. However, Heckler (2014) did not find any difference in the results obtained applying both methods to the same dataset. In fact, one of the major concerns should be the presence of smaller individuals in the samples, which strongly influence the shape of the growth curve, and hence its growth parameters. Our results indicate that seasonal oscillation should be considered when estimating growth parameters for *X. kroyeri* even in tropical waters such as found in Sergipe. The estimated parameters are within the range observed for Penaeidae in general (Figure 10). However, some outliers were observed in this figure, most of them corresponding to *X. kroyeri*, but which result in a lifespan that ranges from 6 to 10 years, which is unrealistically high for seabobs.

The estimated total instantaneous mortality rate (Z) was higher for males (11.81 year^{-1}) than females (5.37 year^{-1}), corresponding to longevity of 3.0 years for females and 2.7 for males. These mortality rates are very high and may suggest that the sampling scheme was biased against large (old) specimens, in addition to incorporating a high rate of fishing mortality. In other studies, longevity of females was estimated as ranging from 1.2 to 3.2 years and from 1.0 to 2.9 years for males (Heckler, 2014; Davanso, 2015; Oliveira, 2015). Fernandes *et al.* (2014) pointed out that mortality rates estimated for males of *X. kroyeri* were always higher than for females (even when using different methods), as

Table 2. Sex ratio of *Xiphopenaeus kroyeri* along the Brazilian coast.

State	Locality	N	F:M	Year	Source	Note
Pará	Curuçá estuary	593	1.45*	2003–2004	Carvalho *et al.* (2015)	Differences among months and/or length classes
Pernambuco	Sirinhaém	1201	1.28*	2011–2012	Lopes *et al.* (2014)	Differences among months and/or length classes
Alagoas	Pontal do Peba	4267	1.09*	2010	Tonial (2011)	Differences among months and/or length classes
Sergipe	Littoral	13,035	0.98	2015–2016	This study	Differences among months and/or length classes
Sergipe	Between Sergipe and Vaza-Barris Rivers	6418	1.17	2013–2014	Silva (2016)	Differences among months and/or length classes
Bahia	Caravelas	1765	1.05	1998–1999	Santos & Ivo (2000)	Differences among months and/or length classes
Espírito Santo	Littoral	2713	0.87	2003–2004	Martins *et al.* (2013)	Differences among months and/or length classes
Rio de Janeiro	Atafona (North of the state)	21,055	1.03	2005–2010	Fernandes *et al.* (2011)	No additional information
São Paulo	Ubatuba Bay	509,729	1.00	1998–2003	Castilho *et al.* (2015)	No additional information
São Paulo	Ubatuba Bay	6470	1.13*	2005–2007	Heckler *et al.* (2013b)	Differences among months and/or length classes
São Paulo	Santos/São Vicente	4831	1.02	2008–2009	Heckler *et al.* (2013a)	Differences among months and/or length classes
Paraná	Littoral	5451	1.03	2004–2005	Natividade (2006)	Differences among months and/or length classes
Santa Catarina	Barbitonga Bay	4007	1.33*	2010–2011	Grabowski *et al.* (2014)	Differences among months and/or length classes
Santa Catarina	Itajaí, Mouth of Itajaí-Açú Rivers	3965	1.15*	1996–1997	Branco *et al.* (1999)	Differences among months and/or length classes
Santa Catarina	Armação do Itapocoroy, Penha	6990	0.95	1996–2001	Branco (2005)	Differences among months and/or length classes

N, sample size; F:M, proportion of females to males.
*Statistically significant difference ($\chi^2 > 3.84$; $P < 0.05$).

Table 3. Intercept (a) and slope (b) for the weight-length relationship ($LW = aCL^b$) for *Xiphopenaeus kroyeri* along the Brazilian coast.

State	a		b		CL min-max (mm)		N		r²		Source
	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	
Pará	0.0007	0.0009	2.770	2.670	–	–	252	242	0.690	0.540	Carvalho *et al.* (2015)
Rio Grande do Norte	0.0022	0.0025	2.391	2.734	12.00–25.00	12.00–24.00	–	–	–	–	Ivo & Santos (1999)
Pernambuco	0.0018	0.0019	2.624	2.637	9.00–27.00	14.00–24.00	–	–	–	–	Ivo & Santos (1999)
Alagoas	0.0013	0.0003	2.612	3.156	5.71–32.68	6.36–31.17	2222	2045	0.864	0.894	Tonial (2011)
Sergipe/Alagoas	0.0013	0.0019	2.651	2.590	9.00–29.00	12.00–23.00	–	–	–	–	Ivo & Santos (1999)
Sergipe	0.0015	0.0001	2.654	2.821	5.90–30.18	7.33–25.09	3900	3825	0.953	0.931	This study
Bahia	0.0014	0.0012	2.706	2.777	5.00–38.00	6.00–32.00	22,086	22,523	0.960	0.940	Guimarães (2009)
São Paulo	0.0034	0.0012	2.578	2.816	–	–	326	572	0.880	0.760	Heckler (2014)

LW, live weight (g); CL, carapace length (mm); CL min-max, minimum and maximum carapace length; N, sample size; r², coefficient of determination.

Table 4. Length at first maturity (CL_{50}), asymptotic carapace length (CL_∞) and ratio between them for females and males of *Xiphopenaeus kroyeri* along the Brazilian coast.

State	CL_{50} (mm)		CL_∞ (mm)		CL_{50}/CL_∞		Source
	Females	Males	Females	Males	Females	Males	
Rio Grande do Norte	13.5	–	–	–	–	–	Santos *et al.* (2013)
Pernambuco	19.5	–	31.26	–	0.62	–	Lopes *et al.* (2014)
Sergipe	12.5	12.0	30.79	28.79	0.40	0.41	Silva (2016)
Sergipe	15.8	12.9	33.00	31.00	0.47	0.42	This study
Bahia	14.5	–	–	–	–	–	Santos & Silva (2008)
Bahia	13.8	–	37.2	–	0.37	–	Santos & Ivo (2000)
Espírito Santo	18.3	–	–	–	–	–	Martins *et al.* (2013)
Rio de Janeiro	22.0	12.0	31.40	26.70	0.71	0.45	Fernandes *et al.* (2011)
Rio de Janeiro	21.3	12.5	32.87	28.4	0.65	0.44	Oliveira (2015)
São Paulo	15.5	14.8	35.33	29.31	0.44	0.50	Castilho *et al.* (2015)
São Paulo	15.8	15.5	31.72	25.47	0.49	0.61	Santos (2014)
Paraná	18.72	–	38.05	–	0.49	–	Natividade (2014)
Santa Catarina	15.9	14.2	31.12	25.81	0.51	0.54	Branco (2005)

they are related to different growth rates (Dall *et al.*, 1990). The same pattern of higher mortality for males was found in Rio de Janeiro and São Paulo (Freire, 2005; Fernandes *et al.*, 2011). An inverse trend was observed in the state of Pernambuco, with higher mortality for females (10.6 year^{-1}) in relation to males (4.51 year^{-1}; Lopes *et al.*, 2014). This result is doubtful, as it is the only study showing such an inverse pattern along the Brazilian coast. In the state of Paraná, mortality rates for both sexes were very similar (Natividade, 2014). Different levels of mortality rates estimated for *X. kroyeri* reflect different levels of exploitation for this species along the Brazilian coast. Atlantic seabob catches are the highest in the state of Sergipe (Thomé-Souza *et al.*, 2014), which explains the high mortality rate estimated for this state. Overall, longevity estimated for Sergipe (low latitude) was higher than in higher latitudes, which is contrary to the latitudinal paradigm. This was also shown for observed maximum length, CL_∞, and length at first maturity. High longevity (2.7 years for females and 2.3 years for males) had already been previously reported at a low latitude (17°S in Caravelas, State of Bahia; Santos & Ivo, 2000). Many authors attribute this counteracting pattern to methodological differences in the estimation process, e.g. FiSAT *vs* PeakFit (Freire, 2005), but also to the possibility of occurrence of more than one species along the South-western Atlantic coast, bias in sampling larger individuals, and exploitation status of these stocks (Grabowski *et al.*, 2014). Moreover, an unbalanced availability of local studies may contribute for this counteracting effect, as most of the studies are concentrated in larger latitudes where stocks are already overexploited.

The results presented here, referring to the period 2015–2016, show the possibility of using fishery-dependent data to estimate basic population parameters for *X. kroyeri* in Sergipe, and largely confirm the results of Silva (2016) who analysed fishery-independent data for 2013–2014 from an area close to the estuary of the Sergipe River. It is hoped that a monitoring system will be put in place that is able to continuously monitor the seabob population off Sergipe, at a low cost, to assess the efficiency of current management measures. This system should also include fishers in the management process, and lead to results that are widely discussed among scientists, fishers and managers.

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