



Aspects of the reproductive biology and characterization of Sciaenidae captured as bycatch in the prawn trawling in the northeastern Brazil

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ABSTRACT. The Brazilian prawn fishery, as other bottom trawling fisheries, is considered quite efficient in catching the target species but with low selectivity and high rates of bycatch. The family Sciaenidae prevails among fish species caught. The study was conducted in the Pernambuco State (Barra de Sirinhaém), northeastern Brazil. From August 2011 to July 2012, 3,278 sciaenid specimens were caught, distributed into 16 species, 34.2% males and 41.5% females. *Larimus breviceps*, *Isopisthus parvipinnis*, *Paralonchurus brasiliensis* and *Stellifer microps* were the most abundant species. The area was considered a recruitment and reproduction area with the highest reproductive activity between December 2011 and July 2012. The constant frequency of mature *I. parvipinnis* and *S. microps* in catches throughout the year suggests that these species are multiple spawners and use the area during their reproductive period. Since most individuals caught as bycatch have not reached sexual maturity, evidencing the need for a better monitoring of the area and the Sciaenidae caught as bycatch, once this incidental caught can cause fluctuations in the recruitment, increasing the proportion of immature individuals in the population and negatively affecting the reproductive success of the species.

Keywords: Demersal, trawling, sexual maturity, coastal zone.

Aspectos da biologia reprodutiva e caracterização de cianídeos capturados como fauna acompanhante da pesca de camarão no nordeste do Brasil

RESUMO. As pescarias de arrasto são consideradas bastante eficientes na captura das espécies-alvo, porém apresentam baixa seletividade, capturando grande quantidade de fauna acompanhante. Entre as espécies capturadas, a família Sciaenidae é quase sempre dominante. A área de estudo está localizada no Estado de Pernambuco (Barra de Sirinhaém), região Nordeste do Brasil. Durante o período de agosto/11 a julho/12 foi capturado um total de 3.278 cianídeos, divididos entre 16 espécies, sendo 34,2% machos e 41,5% fêmeas. *Larimus breviceps*, *Isopisthus parvipinnis*, *Paralonchurus brasiliensis* e *Stellifer microps* foram as espécies mais abundantes. A área estudada foi considerada zona de recrutamento e reprodução, com os maiores índices de atividade reprodutiva entre os meses de dezembro/11 e julho/12. A constante captura de indivíduos maduros de *I. parvipinnis* e *S. microps*, durante todo o período de amostragem, sugere que estas espécies possuem desova múltipla e utilizam a área durante seu período reprodutivo. Devido a maioria dos indivíduos capturados como fauna acompanhante não terem alcançado sua maturidade sexual, é necessário melhor monitoramento da área estudada, assim como dos cianídeos capturados, uma vez que essa captura acidental pode causar flutuações nos processos de recrutamento, aumentando a proporção de imaturos, prejudicando, o processo reprodutivo das espécies.

Palavras-chave: Demersal, arrasto, maturidade sexual, zona costeira.

Introduction

Bottom trawling is highly unselective and tends to produce heterogeneous results with large amounts of bycatch (McCAUGHRAN, 1992) and organisms of a wide size range (KLIPPEL et al., 2005). In a review, Kelleher (2005) estimated that approximately seven million tons of bycatch are

discarded worldwide each year, corresponding to almost 8% of the total landing. This study estimated that the annual bycatch discarded by Brazilian fisheries was of the order of 55 thousand tons.

Fish populations are the most affected by bottom trawling, due to the catch of many juvenile individuals or even breeding stock, thus impeding

spawning (PINA; CHAVES, 2009). Diamond et al. (2000) concluded that the extensive capture of juveniles by bottom trawlers has a major impact on the stocks of sciaenidae in the North Atlantic. The family Sciaenidae is a major component of the bycatch and some of its species - such as the croaker (*Micropogonias furnieri*) and weakfish (*Cynoscion* spp.) - have considerable commercial value, in particular in southern Brazil, where they are among the most common species found in local markets (MENEZES; FIGUEIREDO, 1980; BERNARDO et al., 2011).

Considering both the economic importance of these groups and their considerable taxonomic diversity, further data on the ecology and biology of this family are required, in particular for a better understanding of the effects on the reproductive dynamics and population parameters of species caught as bycatch. While a number of studies on Brazilian Sciaenidae are available, most have focused on stocks in the south of the country (COELHO et al., 1987; CHAVES; VENDEL, 1997; ALMEIDA; BRANCO, 2002; ROMERO et al., 2008; PINA; CHAVES, 2009) and very few data are available on the reproductive biology of sciaenid species, mainly in Northeast Brazil.

The present study focuses on the reproductive biology of *Larimus breviceps*, *Isopisthus parvipinnis*, *Paralonchurus brasiliensis* and *Stellifer microps*, the principal Sciaenidae species caught as bycatch of prawn trawling in the northeastern Brazilian Pernambuco State.

Material and methods

The study area is located in the coastal region of the district of Barra de Sirinhaém, southern Pernambuco State, 70 km south to the capital, Recife (Figure 1). Data were collected each month from August 2011 and July 2012, on board of a local 9-meter wooden-hulled fishing vessel that operates a double trawl, at a depth of approximately 20m. The target species of the fishery are the Penaeid shrimps, mainly the bob-shrimp (*Xiphopenaeus kroyeri*), white-shrimp (*Litopenaeus schmitti*) and the pink-shrimp (*Farfantepenaeus subtilis*). Each sample was based on three trawls with an approximate duration of 2 hours each. Fish collected were kept in a Styrofoam box and taken to the laboratory for analysis.

Species were identified based on the specific taxonomic keys (MENEZES; FIGUEIREDO, 1980, 1985; FIGUEIREDO; MENEZES, 1980, 2000). Fish caught were measured (L_t in cm) and weighed (W_t in g) and had their gonads removed. Whenever possible, the macroscopic identification of the sex of the specimen, and its maturity, based on Vazzoler

(1996) A – immature, B – maturing, C – mature and D – spent), were registered.

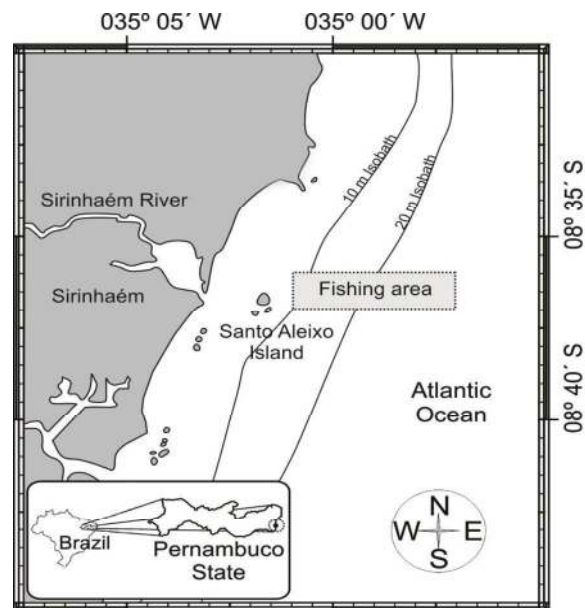


Figure 1. Northwestern Brazil showing location of study area in Barra de Sirinhaém, State of Pernambuco, Brazil.

Source: Lopes et al. (2014).

Sex ratio was determined for the study period as a whole, and for each species, bimonthly. A more detailed description of the reproductive biology was performed for the most common species captured during the study period. The mean total length at which 50% of the individuals had reached sexual maturity (L_{50}) was calculated. To estimate this parameter, stages B, C and D were used. Estimates were based on the graphic extrapolation method, for females and males separately, using the logistic equation proposed by King (2007): $P = 1 / (1 + e^{-r(L - L_{50})})$, where P = the proportion of adult individuals, L = maximum length, L_{50} = total length that corresponds to 0.5 (50%) proportion of the individuals and r = the angle of the curve.

The reproductive period was identified by calculating the Gonadosomatic Index (GSI) bimonthly for the females in maturity classes C and D, based on Vazzoler (1996): $GSI = (W_g/W_t) \cdot 100$, where W_g = gonad weight and W_t = total weight of the specimen. For a more systematic interpretation of the data, the gonadal condition factor (ΔK) or gonadal index was calculated for females, as proposed by Vazzoler (1996). We used the following formula: $\Delta K = K - K'$; $K = W_g/L_t^b$ and $K' = W_g/L_t^b$, where W_g = total weight (W_t) - gonad weight (W_g), L_t = total length, b = slope of the coefficient of the weight-length ratio, $W_t = a \cdot L_t^b$, was also calculated for females.

Results

A total of 16 Sciaenidae species were identified as bycatch of the trawling caught (Table 1); *Larimus breviceps*, *Isopisthus parvipinnis*, *Paralonchurus brasiliensis* and *Stellifer microps* were the most common species during the study. Overall, 34.2% of these individuals were male (n = 1120) and 41.5% female (n = 1360) (χ^2 ; p < 0.01). It was not possible to confirm the sex of the other 24.4% (n = 798). In general, there was a predominance of females, except for *L. breviceps*, *Nebris*

microps (Cuvier, 1830) and *Stellifer rastrifer* (Jordan, 1889) (χ^2 ; p < 0.01) (Table 1).

Bimonthly, *L. breviceps* presented a significant bias towards males in April and May 2012 (χ^2 ; p < 0.01). *Isopisthus parvipinnis* and *S. microps* presented a significant bias towards females between June and July 2012 (χ^2 ; p < 0.01), and April and May 2012 (χ^2 ; p < 0.01), respectively. However, the sex ratio of *P. brasiliensis* did not vary significantly bimonthly (χ^2 ; p < 0.01) (Table 2).

Table 1. Sciaenidae species caught and their respective number of individuals classified as male (M), female (F) and indeterminate (I), as well as sex ratio of males and females. The main species are in bold.

Species	F	M	I	Sex Ratio (M:F)	Total
<i>Larimus breviceps</i> (Cuvier, 1830)	164	205	203	1.3:1*	572
<i>Stellifer microps</i> (Steindachner, 1864)	281	196	71	0.7:1*	548
<i>Isopisthus parvipinnis</i> (Cuvier, 1830)	140	103	91	0.7:1*	334
<i>Paralonchurus brasiliensis</i> (Steindachner, 1875)	122	97	76	0.8:1	295
<i>Stellifer rastrifer</i> (Jordan, 1889)	113	168	105	1.5:1*	386
<i>Ophioscion</i> sp.	125	102	19	0.8:1	246
<i>Stellifer stellifer</i> (Bloch, 1790)	94	73	37	0.8:1	204
<i>Stellifer brasiliensis</i> (Schultz, 1945)	118	46	22	0.4:1*	186
<i>Macrondon ancylodon</i> (Bloch & Schneider, 1801)	21	18	81	0.9:1	120
<i>Menticirrhus americanus</i> (Linnaeus, 1758)	58	30	25	0.5:1*	113
<i>Cynoscion virescens</i> (Cuvier, 1830)	40	20	36	0.5:1*	96
<i>Micropogonias furnieri</i> (Desmarest, 1823)	20	19	13	1:1	52
<i>Stellifer</i> sp.	37	9	3	0.2:1*	49
<i>Ophioscion punctatissimus</i> Meek & Hildebrand, 1925	23	17	4	0.7:1	44
<i>Nebris microps</i> (Cuvier, 1830)	4	16	11	4.0:1*	31
<i>Menticirrhus littoralis</i> (Holbrook, 1847)	-	1	1	-	2
Total	1,360	1,120	798	0.8:1*	3,278

*Significant at 5%.

Table 2. Variation in sex ratio and length range (minimum and maximum in centimeters) of *Larimus breviceps*, *Paralonchurus brasiliensis*, *Isopisthus parvipinnis* and *Stellifer microps* caught from August 2011 to July 2012 at Barra de Sirinhaém – Brazil.

Months	n / Male	n / Female	Length range (cm)	M:F	p
Aug/11 - Sep/11					
<i>Larimus breviceps</i>	26	19	6.0 - 17.0	1.4:1	0.297
<i>Paralonchurus brasiliensis</i>	14	25	7.5 - 20.0	0.6:1	0.078
<i>Isopisthus parvipinnis</i>	3	8	6.6 - 15.6	0.4:1	0.132
<i>Stellifer microps</i>	4	6	7.0 - 14.2	0.67:1	0.527
Oct/11 - Nov/11					
<i>Larimus breviceps</i>	9	15	8.5 - 14.5	0.6:1	0.221
<i>Paralonchurus brasiliensis</i>	6	14	9.0 - 18.0	0.4:1	0.074
<i>Isopisthus parvipinnis</i>	20	20	6.0 - 22.7	1:1	1.000
<i>Stellifer microps</i>	12	13	7.5 - 16.0	0.92:1	0.841
Dec/11 - Jan/12					
<i>Larimus breviceps</i>	27	26	8.5 - 19.9	1:1	0.891
<i>Paralonchurus brasiliensis</i>	5	7	8.3 - 20.6	1.0:1	0.564
<i>Isopisthus parvipinnis</i>	14	13	7.5 - 19.8	1.1:1	0.847
<i>Stellifer microps</i>	27	36	6.8 - 17.7	0.75:1	0.257
Feb/12 - Mar/12					
<i>Larimus breviceps</i>	66	64	8.0 - 17.7	1:1	0.861
<i>Paralonchurus brasiliensis</i>	26	28	9.7 - 18.5	1.0:1	0.785
<i>Isopisthus parvipinnis</i>	32	39	8.7 - 19.8	0.8:1	0.406
<i>Stellifer microps</i>	110	141	7.0 - 19.5	0.78:1	0.050
Apr/12 - May/12					
<i>Larimus breviceps</i>	43	16	6.6 - 17.0	2.7:1	0.0004*
<i>Paralonchurus brasiliensis</i>	35	40	9.6 - 18.3	0.9:1	0.564
<i>Isopisthus parvipinnis</i>	16	23	8.5 - 20.4	0.7:1	0.262
<i>Stellifer microps</i>	18	47	8.6 - 15.4	0.38:1	0.0003*
Jun/12 - Jul/12					
<i>Larimus breviceps</i>	34	24	6.5 - 23.2	1.4:1	0.189
<i>Paralonchurus brasiliensis</i>	4	8	7.0 - 18.7	0.4:1	0.248
<i>Isopisthus parvipinnis</i>	18	37	11.0 - 19.8	0.5:1	0.0104*
<i>Stellifer microps</i>	25	38	5.7 - 16.8	0.66:1	0.101
Total					
<i>Larimus breviceps</i>	205	164	6.0 - 23.2	1.3:1	0.0328*
<i>Paralonchurus brasiliensis</i>	90	122	7.0 - 20.6	0.8:1	0.075
<i>Isopisthus parvipinnis</i>	103	140	6.0 - 22.7	0.7:1	0.0176*
<i>Stellifer microps</i>	196	281	5.7 - 19.5	0.7:1	0.0001*

*Significant at 5%.

The L_{50} of *L. breviceps* was estimated as 13.3 and 13.5 cm for males and females, respectively (Figure 2A). Based on the L_{50} for both sexes of *L. breviceps* (14.04 cm) approximately 80.2% of the specimens collected were in the $L_t < L_{50}$ class, with a mean length of 11.82 cm ($sd = \pm 3.38$) (Figure 3A), reflecting the predominance of juveniles in the sample collected in the present study. For *I. parvipinnis*, L_{50} was 14.5 cm for females and 13.2 cm for males (Figure 2B), and according to the L_{50} for both sexes (14.4 cm) approximately 60% of the specimens of this species were in the $L_t > L_{50}$ class, with a mean length of 14.94 cm ($sd = \pm 3.74$) (Figure 3B). For *S. microps*, L_{50} was estimated as 8.22 cm for females, 12.52 cm for males (Figure 2C) and 10.4 cm for both sexes, with a predominance of the size classes above this point (approximately 60%), with a mean length of 11.71 cm ($sd = \pm 2.37$) (Fig. 3C). *Paralonchurus brasiliensis*, which had L_{50} estimated as 14.92 cm for males, 13.53 cm for females (Figure 2D) and 14.7 cm for grouped sexes. This species showed the highest frequency of

occurrence for the length classes below L_{50} for both sexes (57% of the specimens), with a mean size of 13.57 ($sd = \pm 2.49$ cm) (Figure 3D).

Larimus breviceps exhibited the highest Gonadosomatic Indices (GSI) between December 2011 and March 2012. The curve of the gonadal condition factor (ΔK) was similar to that of the GSI, with peaks during the same period, which also corresponds to that of the highest percentage of individuals at the developmental stage C. All gonad developmental stages, except D (spent), were observed for *L. breviceps* throughout the study period. A high percentage of immature individuals was recorded, between August and November 2011, and in June and July 2012 (Figure 4). Female *I. parvipinnis* presented a peak in GSI scores in the period between April and July 2012, with a high percentage of mature females in these months, while no reproductively active females (stages C and D) were observed in August and September 2011. In addition, individuals with spent gonads were common between November 2011 and July 2012 (Figure 4).

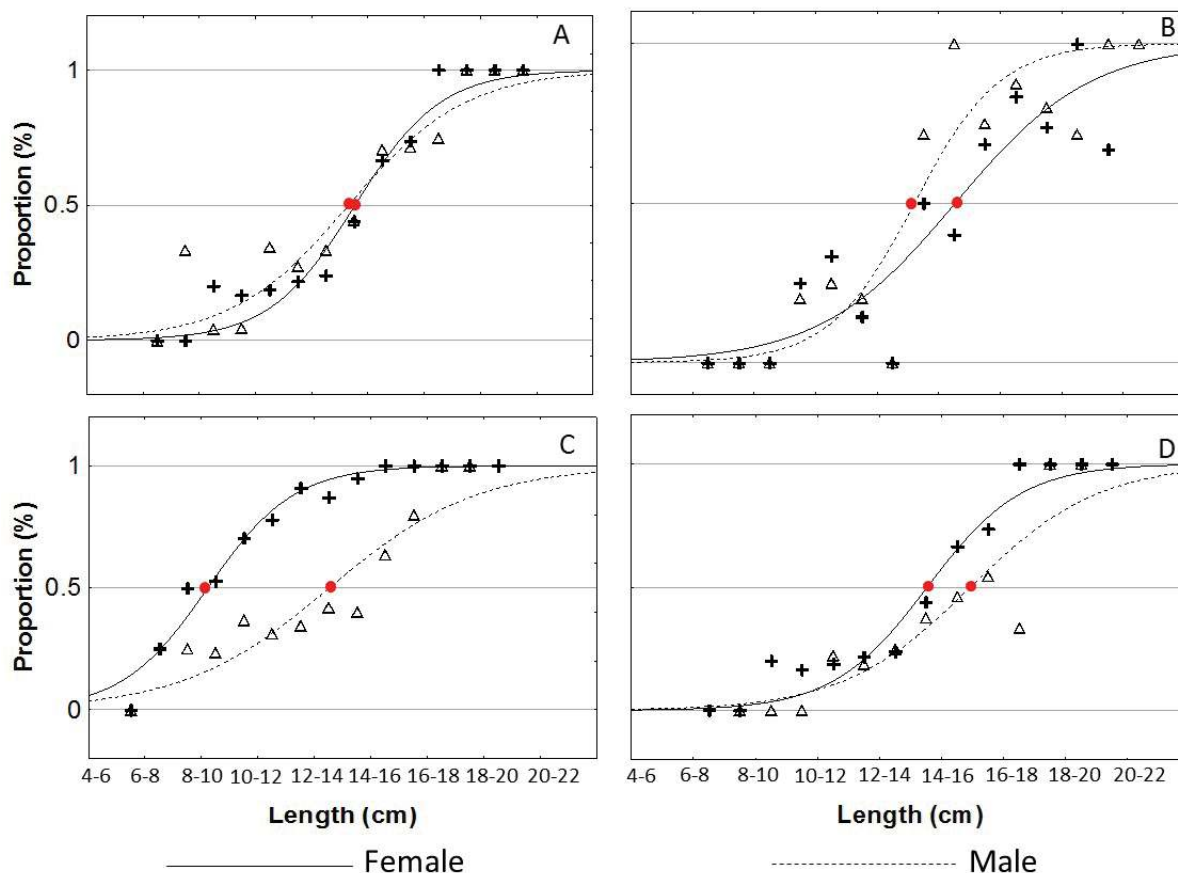


Figure 2. Length of first maturity of (A) *Larimus breviceps*, (B) *Isopisthus parvipinnis*, (C) *Stellifer microps* and (D) *Paralonchurus brasiliensis* caught from August 2011 to July 2012, Barra de Sirinhaém – Brazil.

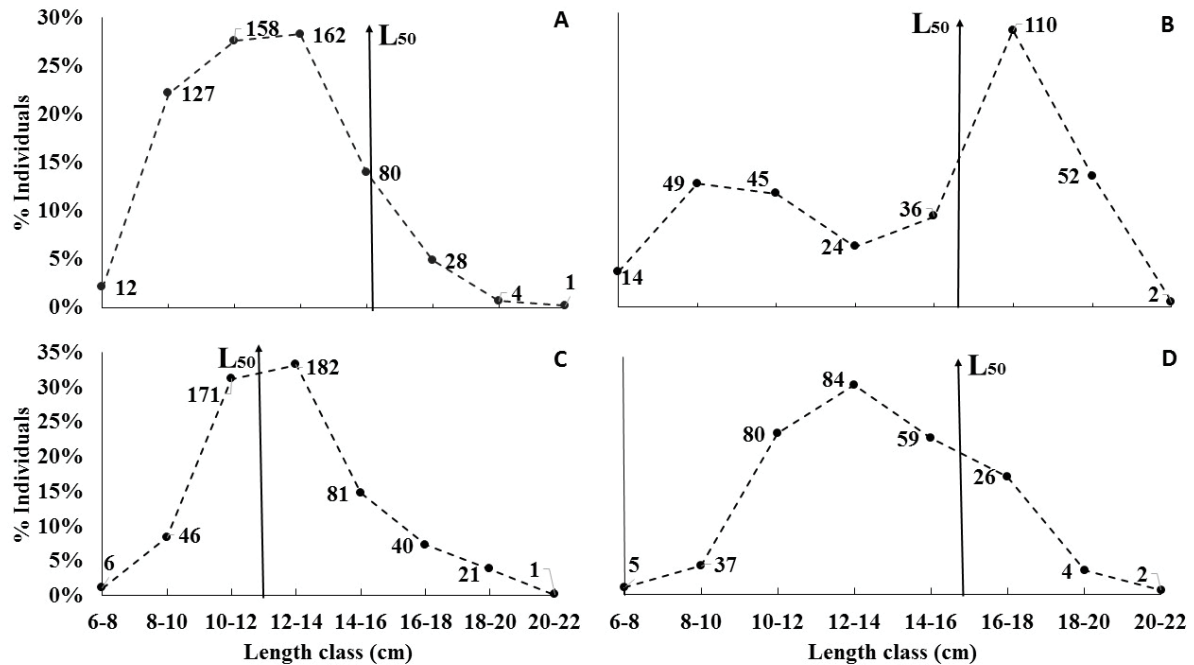


Figure 3. Percentage of individuals of (A) *Larimus breviceps*, (B) *Isopisthus parvipinnis*, (C) *Stellifer microps* and (D) *Paralonchurus brasiliensis* caught from August 2011 to July 2012 in Barra de Sirinhaém - Brazil, according to length classes. The numbers above the dashed line represents the sample size (N); the vertical line indicates the estimated size of first sexual maturity (L_{50}) for grouped sexes.

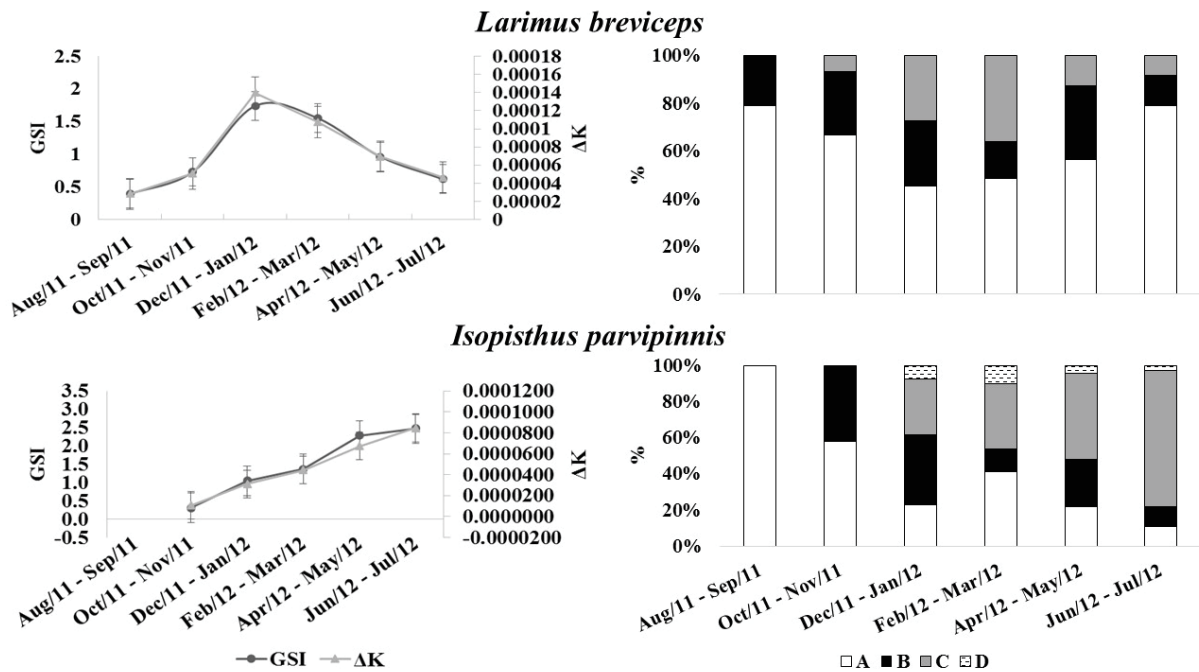


Figure 4. Mean Gonadosomatic Index and Gonadal Condition Factor (ΔK), and percentage frequency of maturity stages of female *Larimus breviceps* (above) and *Isopisthus parvipinnis* (below), respectively, caught from August 2011 to July 2012 in Barra de Sirinhaém - Brazil. A: immature, B: maturing, C: Mature and D: Spent.

During the study period, the GSI and ΔK curves for *S. microps* slightly varied over the year, with two peaks, one between December 2011 and January 2012, and a second between April and May 2012.

Based on the bimonthly distribution of the different maturity stages, reproductively active female *S. microps* were present throughout the study period. Immature individuals were more common between

October 2011 and February 2012, peaking in October and November 2011 (Figure 5). The GSI and ΔK values recorded for *P. brasiliensis* varied little over the study period, with reduced number of reproductively active fish (stages C and D), representing only 7% of the specimens. By contrast, individuals in stages A (immature) and B (maturing) were predominant (Figure 5).

Discussion

While sciaenidae dominated the bycatch of prawn trawling, their captures during this activity are usually discarded due to the lack of commercial value. Sciaenidae typically inhabit coastal areas, where bottom prawn trawling is concentrated, especially for breeding and recruitment, which occurs between December and June in Brazilian waters, for most species (ROBERT et al., 2007). A similar seasonal pattern was recorded in the present study, with peaks in GSI for most species especially between December 2011 and June 2012, preceding the rainy season in this region.

When a large proportion of individuals (of any species) in the initial stages of reproductive activity is being harvested, there may be fluctuations in the recruitment process, resulting in an imbalance in the age structure of the stocks, increasing the proportion

of juveniles, which may cause a reduction in the size at first sexual maturity (VAZZOLER, 1996). This would compensate for the effects of mortality caused by fishing, but would likely result in reduced fecundity and increased vulnerability to predators (FONTELES-FILHOS, 2011). In the present study, the proportion of adults was greater than juveniles for *I. parvipinnis* and *S. microps*, whereas for *L. breviceps* and *P. brasiliensis*, juvenile individuals predominated.

These estimates were based on the number of specimens smaller than the size at first maturity (L_{50}), which was consistent with the data available for these species in other regions. The size at first maturity observed for grouped sexes of *P. brasiliensis* and *I. parvipinnis* were close to those observed by some authors mainly for the Southern region of Brazil (LEWIS; FONTOURA, 2005; ROMERO et al., 2008). For *Stellifer microps*, only information related to individuals records are available, without detailed information on their biology (BARLETTA et al., 2005; BARROS et al., 2011). However, for *Stellifer rastrifer*, Rodrigues-Filho (2001) estimated the size of sexual maturity close to that reported in this study, where the females and males of this species reached their first maturity in the same length range of *S. microps*.

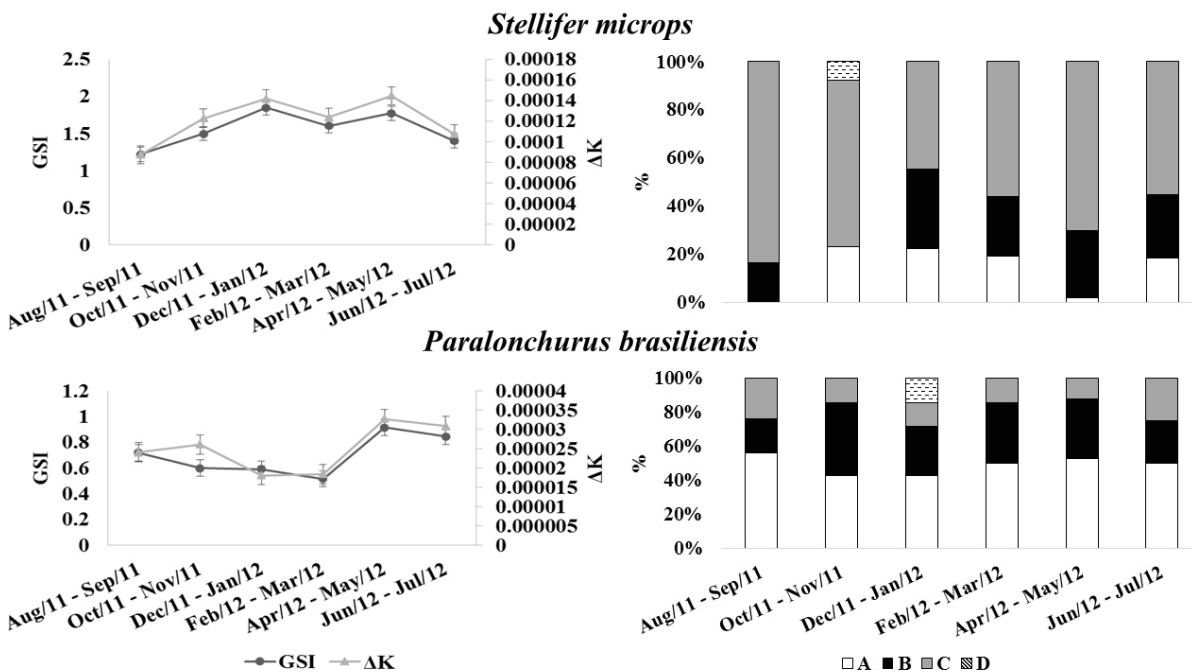


Figure 5. Mean Gonadosomatic Index and Gonadal Condition Factor (ΔK), and percentage frequency of maturity stages of female *Stellifer microps* (above) and *Paralonchurus brasiliensis* (below), respectively, caught from August 2011 to July 2012 in Barra de Sirinhaém – Brazil. A: Immature, B: Maturing, C: Mature and D: Spent.

According to the region and the characteristics of the fishing gear used, the trawling may have distinct effects on the population structure of a given fish species, resulting from factors such as seasonal variation in the population structure or the trawl depth (COELHO et al., 1988). In the cases of *L. breviceps* and *P. brasiliensis*, trawling affects mainly the juveniles. However, Branco et al. (2005) observed the opposite pattern in *P. brasiliensis* on the southern Santa Catarina State, where most individuals in the bycatch of prawn trawlers were adults. These differences could be related to the selectivity of the gear used and/or the spatial segregation of adults and juveniles. Robert et al. (2007) concluded that juvenile *P. brasiliensis* (body length of less than 9.3 cm) remain close to the beach, at depths of less than 10 m, until reaching maturity, and only then migrate to other areas before returning, generally with a body length of over 13 cm, to complete gonadal maturation. In the present study, the area trawled is close to the coast and has a mean depth of 10 m, which may account for the high percentage of immature specimens caught.

While the presence of individuals with mature gonads in a given area is not a conclusive evidence that it constitutes a breeding ground (VAZZOLER, 1996), the constant occurrence of mature individuals throughout the year in Barra de Sirinhaém suggests that the study species may use this area during their reproductive period and follow an asynchronous spawning strategy. *Larimus breviceps* presented intense reproductive activity during the months of the austral summer.

The results of the present study indicate that the recruitment of *L. breviceps* and *P. brasiliensis* occurs practically throughout the year, given the predominance of immature specimens during most months of the study period. Recruitment of *I. parvipinnis* and *S. microps* appears to be more intense during the austral spring and summer, respectively. In the case of *I. parvipinnis* in Guaratuba Bay, southern Paraná State, Chaves and Corrêa (1998) observed an absence of juveniles and a predominance of adults in the estuary and adjacent mangrove areas, indicating that this species migrates to bays and mangroves during the reproductive period. Our results suggest that Barra de Sirinhaém represents a transition zone for *I. parvipinnis*, and thus an area of considerable ecological importance for the species, given the proximity of this area to estuaries and mangroves, supported by the evidence of reproductive activity and the marked presence of juveniles. The recruitment of *S. microps* occurs primarily between October and February, the same period identified for *S. stellifer* at Armação do Itapocoroy, in Santa Catarina State, by Almeida and Branco (2002).

In general, considering all the species in the present study, the results highlight the need to develop management methods to reduce and mitigate the impacts of trawling on the immature individuals and on the various species caught by this type of fishing gear. Such mechanisms may include (i) the implementation of fisheries exclusion zones, (ii) the establishment of closed seasons during the main breeding periods of the fish species, and (iii) the prohibition of small mesh sizes or the addition of escape mechanisms to the nets. Nevertheless, it is clear that such management decisions would be very hard to enforce in a very small-scale artisanal fishery in terms of logistics and political aspects.

In the present study, the establishment of effective measures for the mitigation of impacts will require more data (including other areas and different depths) and the more systematic monitoring of the impacts caused by bottom trawling for prawns in the study area, in order to confirm the patterns identified in the present study. Ultimately, data on the ecological characteristics and capture patterns of the target prawn species should also be integrated into any management plan.

Conclusion

The coastal region of the district of Barra de Sirinhaém was considered a recruitment and reproduction area with the highest reproductive activity between December 2011 and July 2012. According the constant frequency of mature individuals of *I. parvipinnis* and *S. microps* in catches over the year, we suggest that these species are multiple spawners and use the area during their reproductive period. The great occurrence of immature individuals of *L. breviceps* and *P. brasiliensis*, based on the L_{50} , suggest that these species use this area during their recruitment period.

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