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Size structure of the pink shrimp, *Farfantepenaeus paulensis* (Pérez-Farfante, 1967) (Decapoda: Penaeoidea), in a subtropical estuary: an assessment motivated by demand from fishermen

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Abstract. Artisanal fishermen of pink shrimp (*Farfantepenaeus paulensis*) from Patos Lagoon estuary have called for changes in the legislation that controls this fishery. They would like the opening of the season to change from a fixed calendar to a floating calendar that is controlled by the time that the shrimp reach the minimum landing size. They asked for the release of the use of otter-trawls nets, arguing that they can capture larger shrimp than with the permitted fishing gear (fyke-nets). We analyzed the size structure of the pink shrimp captured with otter-trawls and focused on the capture proportions of shrimp that are larger and smaller than the capture size defined by the legislation (90 mm total length). The shrimp harvested by trawl were not in accordance with the minimum size required by law. The month, region, and fishing depth exerted influence on the variability of the proportions of shrimp larger and smaller than allowed. Therefore, it is recommended that the current legislation remains in place. However, if there is an approval for this demand, the shrimp measurements to release the season must be conducted in multiple regions of the estuary due to the variability of the shrimp sizes according to the region.

Keywords: otter-trawl, fishery, minimum size of capture.

Resumo. Estrutura de tamanho do camarão-rosa em um estuário subtropical: um estudo otivado pela demanda dos pescadores. Os pescadores artesanais de camarão-rosa (*Farfantepenaeus paulensis)* do Estuário da Lagoa dos Patos demandam a mudança da legislação que controla a pescaria. Eles querem que a abertura da safra mude de um calendário fixo para um calendário flutuante, controlado pelo momento em que o camarão alcança o tamanho mínimo de captura. Pedem pela liberação do uso das redes de arrasto de porta para a captura, argumentando que assim capturam camarões maiores que com a arte de pesca permitida ("saquinho" – "*fyke-nets*"). Foi analisada a estrutura de tamanho do camarão-rosa capturado com redes de arrasto de portas, com enfoque na proporção de captura de camarões menores/maiores que o tamanho de captura definido pela legislação (90 mm comprimento

total). Os camarões capturados com rede de arrasto dentro do estuário da Lagoa dos Patos não estavam de acordo com o tamanho mínimo exigido pela legislação. Mês, região, e profundidade de pesca exerceram influência na variabilidade da proporção de camarões maiores/menores que o permitido. Assim, não se recomenda a alteração da legislação atual. Contudo, se for acatada a alteração as medições para a liberação da safra devem ser realizadas em diferentes regiões do estuário, devido a variabilidade de tamanhos dos camarões de acordo com a região.

Palavras chave: arrasto de portas, pesca, tamanho mínimo de captura

Introduction

The pink shrimp (*Farfantepenaeus paulensis*) uses estuarine areas as nursery grounds. Adults spawn in coastal waters, and larvae are passively transported to estuaries and shallow bays by hydrodynamic processes. Once they settle in these coastal environments as post-larvae and develop into juveniles and pre-adults, they are heavily exploited by artisanal fisheries throughout the coast. The pink shrimp life cycle ends with a final reproductive migration out of the estuary, towards the sea to complete their development (Neiva 1966, Iwai 1978, Garcia & Le Reste 1981, D'Incao 1991). The pink shrimp fisheries of the Patos Lagoon estuary, in the state of Rio Grande do Sul, are among the most profitable, and they are important for artisanal fishermen in the region. Pre-juveniles are captured in these fisheries during the season of their migration to the sea in the summer and fall (D'Incao 1991).

The Patos Lagoon estuary is an important fishery sector. There are approximately 3,600 fishermen distributed in the coastal communities along the estuary. The cities with the greatest numbers of artisanal fishermen are São José do Norte (33%), Rio Grande (30%), Pelotas (17%), São Lourenço do Sul and Tavares (3%) (Kalikoski & Vasconcellos 2012).

The Normative Instruction No. 3 (MMA/SEAP 2004) regulates the fisheries in this region and establishes the fishing seasons according to species. The pink shrimp season takes place from February to May as an attempt to allow a portion of the recruits to leave the estuary and replace the oceanic stock. This regulation also prohibits the use of otter-trawl nets, allowing only passive fishing gears to catch pink shrimp (fyke-nets and stow nets). Another important element is the establishment of a minimum capture size of 90 mm in total length (TL), although the legislation tolerates 20% of the catch being composed of smaller individuals.

In the Patos Lagoon estuary, artisanal fisheries are decreasing due to the decline in fishery resources caused by over-exploitation, loss of biodiversity, poverty and loss of the cultural identity of the fisheries communities (Haimovici *et al*. 2006, Kallikoski *et al*. 2002). In a response to the failure of top-down fishery management, the Forum of Patos Lagoon was created. This multi-partner entity is based on a co-management system where a strong link between fishermen and researchers has been established. The purpose of the entity is to discuss and develop alternative actions to mitigate the crisis in the artisanal fisheries sector, recover the important artisanal fisheries, and to share decisions to address problems more effectively (D'Incao & Reis 2002, Kallikoski *et al*. 2002).

Therefore, it is necessary to implement local plans for fishery management that take into consideration all actors and interests, mainly those belonging to traditional communities that depend exclusively on the resource (Kallikosky *et al.* 2006). Kallikosky *et al.* (2006) interviewed the artisanal fishing community from the region to better understand the traditional knowledge of the community. There was a demand for a floating fishing calendar that suits the conditions of the resources. It was also suggested that the opening of the fishing season should be controlled annually, from the time when the shrimp reach the minimum size required by legislation (Reis & D'Incao 2000, Kalikoski *et al.* 2006). These arguments are based on the artisanal fishermen's extensive knowledge of the variations in hydrological conditions, particularly salinity, that affect shrimp production in the Patos Lagoon estuary (Castelo & Möller 1978, Möller *et al.* 2009, Pereira & D'Incao 2012).

However, fishermen defy the law to obtain a better income through fishing with otter-trawls. This fishing gear is widely used across the Patos Lagoon estuary to catch pink shrimp (Benedet *et al.* 2010, Kalikoski & Vasconcellos 2012). Fishermen request the allowance of trawl fishing in the Patos Lagoon estuary. They believe that otter trawls, if operated correctly, capture only the largest shrimp that are migrating to the sea, causing a smaller impact than fyke nets (Kalikoski *et al.* 2006).

Studies on the size of shrimp caught in the Patos Lagoon estuary have been conducted, showing that the percentages of shrimp smaller than 90 mm TL were higher than those allowed by the legislation (Almeida & D'Incao 1999, Ruas *et al.* 2011).

However, these studies were performed with fyke-nets that only operated in the shallow areas of the estuary.

Following the above rationale related by the fishermen, two basic changes to the law were suggested: a) Open the fisheries when the shrimp reach the legal size; and b) Allow trawling in the lagoon. This study aimed to meet the demand of the fishermen and to serve as a tool for management actions. In this regard, we analyzed the size structure of the pink shrimp (*F. paulensis*) captured with otter trawls by artisanal fishermen in the Patos Lagoon estuary. We focused on the percentage of smaller shrimp that is allowed by law and considered aspects such as the monthly, annual and local variations of the size structure of their population.

Materials and methods

The study area was the Patos Lagoon estuary, located in Rio Grande do Sul state, southern Brazil. Sampling occurred through a partnership between the local artisanal fishermen and researchers. The fishing boats and gear were owned by the fishermen. The nets had a 12 mm mesh size between opposite knots in the bag. The researcher, always bearing a license from the competent environmental authority (SISBIO - No. 28975-1), was present only to monitor the fisheries, collect material to be analyzed in the laboratory and obtain the necessary information. In each fishing haul, the salinity at the bottom, the depth of the site and the geographical position were registered. Sampling occurred during 2011-2013, from December to April. These months were chosen because it was known in advance that fishermen start fishing for shrimp in December, although to be in accordance with the law, fishing should start in February.

The samples were not spatially random, as the choice of fishing spots was subjected to the discretion of the fishermen. This approach was used so that the samples represent the local artisanal fisheries, thereby incorporating the fishermen's knowledge about the pink shrimp behavior. Samples were taken from the area that comprises the estuary's mouth, located near the Patos Lagoon jetties (32º09' S 52º05' W), to the upper estuary, near the city of Pelotas (31º43' S 52º08' W). This area was divided into four regions: the estuary's mouth, central estuary, sheltered estuary and upper estuary (Fig. 1). The estuary's mouth is characterized by a long and deep channel for navigation that connects the waters of the estuary and the sea. The central estuary is also an elongated channel, but it is located farther downstream. The protected estuary is a shallow inlet surrounding Marinheiros Island. The upper estuary is the farthest from the sea, an open area relative to the estuary's mouth and the central estuary. The upper estuary also consists of deep channels that flow towards the sea. The fishing hauls were also grouped according to the depth: shallow areas (up to 2 m deep) and channel areas (greater than 2 m deep).

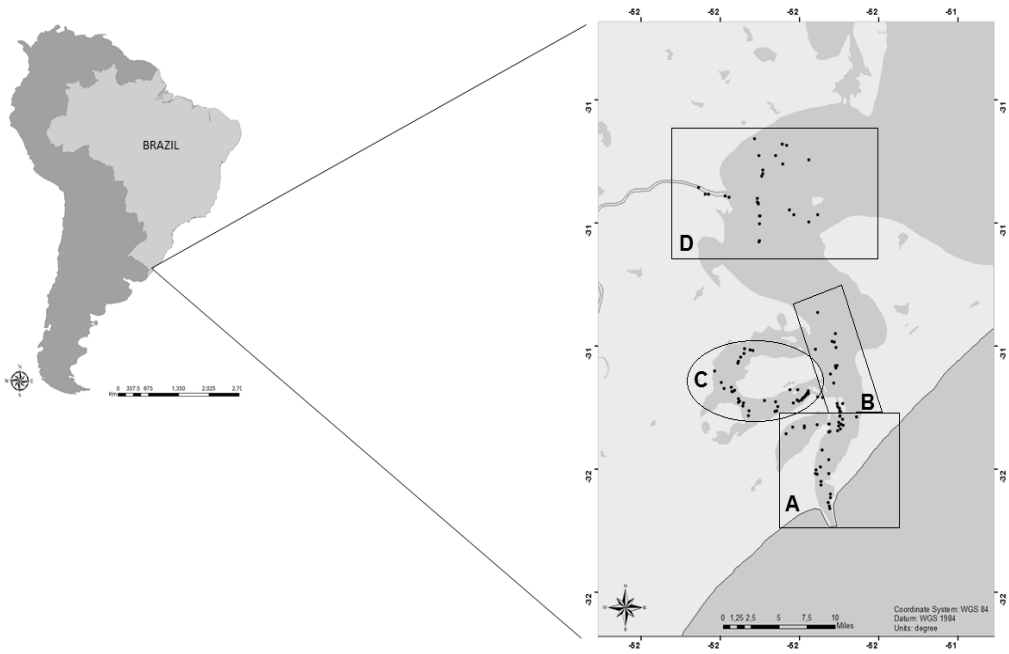

Figure 1. Study area of the Patos Lagoon estuary (Rio Grande do Sul state, Brazil). The points represent locations of the fishing hauls. Outlines of the estuary mouth (A), central estuary (B), sheltered estuary (C) and upper estuary (D) can be observed.

Farfantepenaeus paulensis total length (TL) was measured from the tip of the rostrum to the end of the telson. The specimens were grouped into 3 mm size classes. The vast majority of catches allowed all individuals to be measured. However, when catches were very abundant, only a sub-sample of the capture was measured. All samples were weighed, allowing the extrapolation of the frequency length of the sub-samples to the total catch.

The catch data were standardized into catch per unit effort (CPUE, individuals/15 minutes). The CPUE was analyzed by size class (TL - 3 mm) to check the size structure of the shrimp (Vieira 2006), considering month (December to April), year (2011, 2012, 2013), fishing area (estuary's mouth, central estuary, sheltered estuary and upper estuary) and depth (shallow areas and channel). The percentage of individuals smaller than 90 mm TL was also calculated considering month, year, fishing area and depth. The estimates of the sizes at first capture (P50%), in which there was a 50% probability of the shrimp being caught in the trawl net, were obtained from TL distributions in millimeters, according to the logistic model proposed by Sparre & Venema (1998) for months, years, regions and depths.

A generalized linear model (GLM), performed using the R-3.1.1 software (R Core Team. 2014), was adjusted to analyze the variability of the proportion of shrimp smaller than 90 mm TL in the estuary. First, a model was chosen that included the month (December to April), year (2011, 2012, 2013), region (estuary's mouth, central estuary, sheltered estuary and upper estuary), depth (shallow and channel areas) and bottom salinity (continuous variable) as explanatory variables. The predictive variable was incorporated by the *cbind* function in two columns with the number of shrimp smaller/greater than 90 mm TL. The data were adjusted through the binomial family with the logit link function. The presence of overdispersed data was observed through the *Residual deviance*/*Residual degrees of freedom* relationship. Therefore, the model was adjusted using the quasi-binomial family with the logit link function. The initial model was gradually reduced by excluding non-significant factors from the model through F-tests applied in pairwise comparisons (function: *drop1*; Faraday 2006). *A posteriori* comparisons of the significant factors were performed using the *multicomp* package *GLHT* function, which performs multiple comparisons of means (TukeyHSD function).

Additionally, to determine whether there were differences in the average salinity of the estuary between the years of study, we performed a Kruskal-Wallis test with multiple comparisons. The average salinity was acquired based on the daily measurements taken at seven points distributed along the estuary.

Results

A total of 23,500 individuals were caught, and 35.4% (8,319) were measured. The size frequency distribution showed that the size range of shrimp was from 30 mm TL to 146 mm TL. The calculated P50% was 86.62 mm TL, 54.2% of which was composed of individuals smaller than 90 mm TL (Table I, Fig. 2).

Table I - Description of size classes (TL) observed for shrimp caught with otter trawls in the Patos Lagoon estuary, showing the number of measured specimens (N), size range, size in which the probability of capture is 50% (P50%) with the confidence interval (CI P50%) and percentage of individuals smaller than 90 mm TL (% < 90 mm). Unit of measure: millimeters.

Factor	Variable	N	Size Range	P50%	CI P50%	% < 90 mm
	Total	8319.0	30.0 - 146.0	86.6	86.3 - 86.9	54.2
Month (considering all years)	December	300.0	50.0 - 145.0	78.4	78.1 - 78.7	76.7
	January	2766.0	30.0 - 141.0	92.5	91.9 - 92.9	41.6
	February	2626.0	45.0 - 146.0	81.8	81.5 - 82.2	59.7
	March	2175.0	38.0 - 144.0	84.3	84.1 - 84.5	63.2
	April	451.0	42.0 - 124.0	87.0	87.4 - 87.9	41.5
Year	2011	4623.0	37.0 - 144.0	86.0	85.7 - 86.2	53.3
	2012	2188.0	30.0 - 146.0	82.3	82.1 - 82.4	69.1
	2013	1508.0	37.0 - 145.0	98.9	98.3 -99.5	35.1
Region	Estuary mouth	1857.0	37.0 - 137.0	92.6	92.1 - 93.1	35.6
	Central estuary	3338.0	38.0 - 146.0	87.0	86.7 - 87.2	51.5
	Upper estuary	778.0	51.0 - 118.0	86.5	86.2 - 86.8	54.8
	Sheltered estuary	2346.0	30.0 - 144.0	79.8	79.6 - 79.9	72.6
Depth	Shallow areas	2246	35.0 - 146.0	78.2	77.4 - 78.9	50.5
	Channel areas	3012	30.0 - 137.0	76.6	75.5 - 77.7	64.5

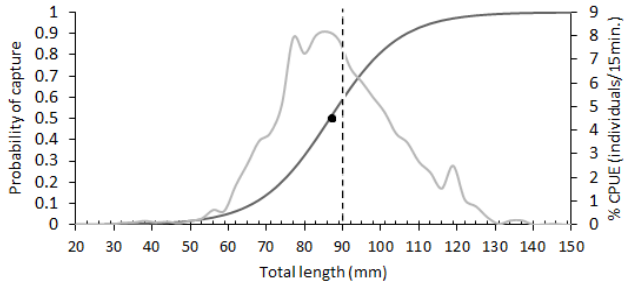

Figure 2. Probability of capture (dark line), where the point marks the size of the first capture (P50%), and CPUE percentage (light line) by size class of the pink shrimp captured with artisanal trawling in the Patos Lagoon estuary. The dashed line represents the shrimp at 90 mm TL.

December had the lowest value of P50% and the highest percentage of shrimp smaller than 90 mm TL. The opposite occurred in January, when the largest shrimp were captured. In February, the size of the shrimp captured declined relative to January but increased relative to December. The March capture exhibited a size pattern similar to February. In April, the pattern was similar to January, presenting higher values of P50% and a small percentage of shrimp smaller than 90 mm TL. Fig. 3 shows a shift to the right in the logistic curve over the months, represented by a higher contribution of larger sizes in CPUE, except January, which showed the least shifted curve (Table I).

Larger shrimp were caught in the estuary's mouth, where the lowest percentage of individuals smaller than 90 mm TL was also observed. The central and upper estuary were intermediate, and the smallest individuals were captured in the sheltered estuary (Fig. 5, Table I). According to the depth, shrimp with the largest size were captured in the channel areas, and the catches in shallow areas presented lower values of L50% and greater percentages of smaller individuals (Fig. 6, Table I).

The values presented in Table I show that the smallest shrimp were caught in 2012, with the lowest value of P50% and the greatest percentage of shrimp smaller than 90 mm TL. The largest shrimp were caught in 2013. The year 2011 was intermediate, with a P50% of 86 mm TL and a percentage of smaller shrimp of 53.3%. Fig. 4 shows a shift to the right in the logistic curve in the sequence 2012, 2011, 2013, a similarity between 2011 and 2012 and a greater contribution of larger sizes in the CPUE percentage in 2013 (Table I).

The adjusted model that explained the variability in the proportion of shrimp smaller than 90 mm TL incorporated the following factors: area (df=3, $F=8.2363$; $P<0.0001$), depth

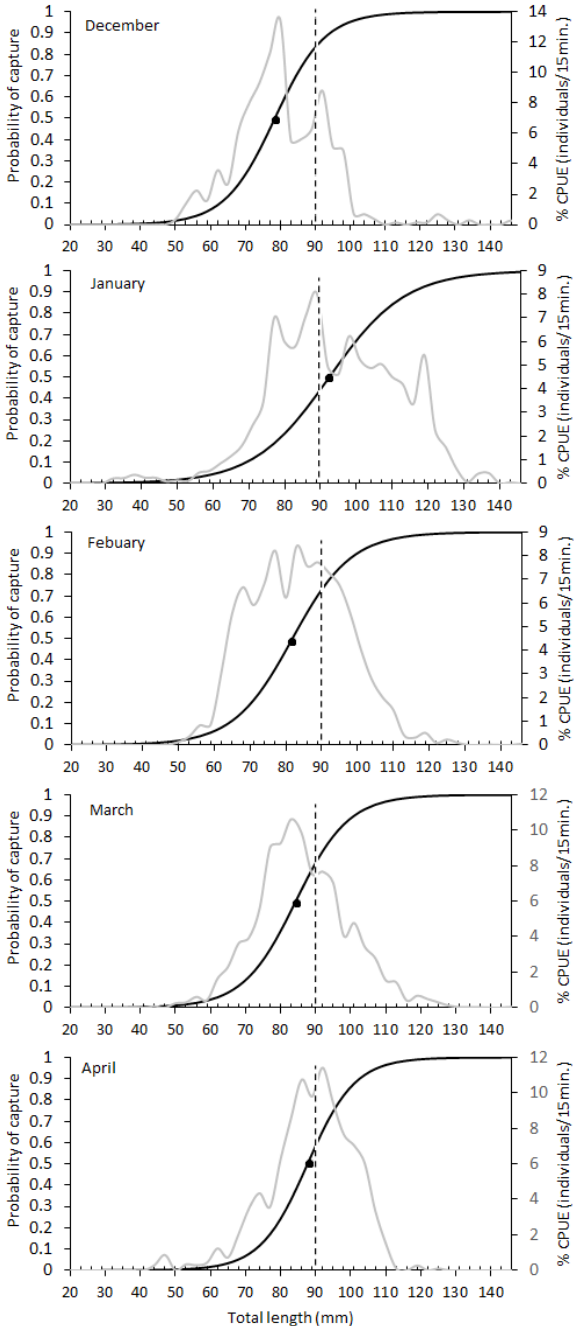

Figure 3. Monthly probability of capture (dark line), where the point marks the size of the first capture (P50%), and CPUE percentage (light line) by size class of the pink shrimp captured with artisanal trawling in the Patos Lagoon estuary. The dashed line represents the shrimp at 90 mm TL.

(df=1, $F=14.786$; $P=0.0002$) and month (df=4, $F=5.3562$, $P=0.0005$) (Table II). The multiple comparison test verified that trawls performed in the central and sheltered estuary captured a greater proportion of small shrimp (<90 mm TL) than those performed in the estuary mouth. The captures in shallow areas included greater proportions of small shrimp than those conducted in the channel areas. January was different from February and March, with a lower proportion of small shrimp captured (Table III).

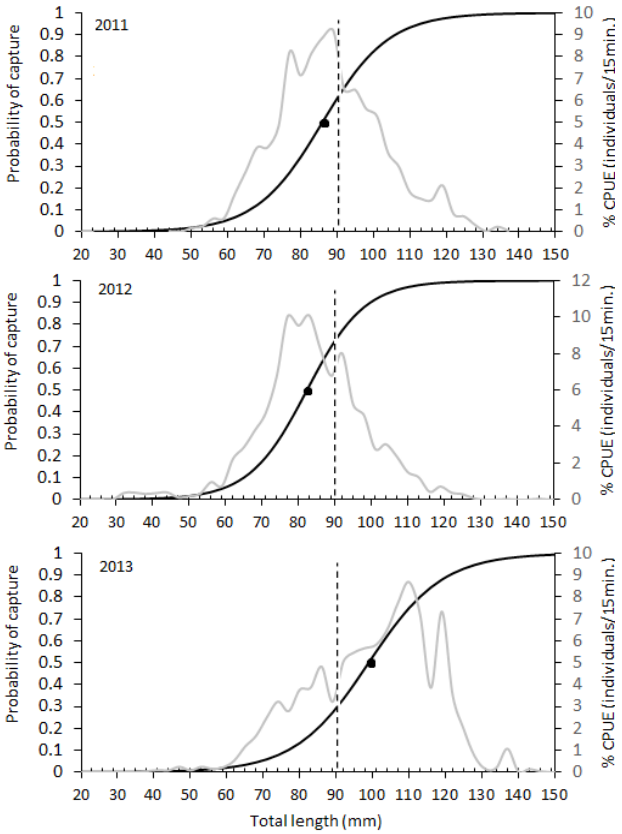

Figure 4. Probability of capture (dark line), where the point marks the size of the first capture (P50%), and CPUE percentage (light line) by size class of the pink shrimp captured with artisanal trawling in the Patos Lagoon estuary over the years. The dashed line represents the shrimp at 90 mm TL.

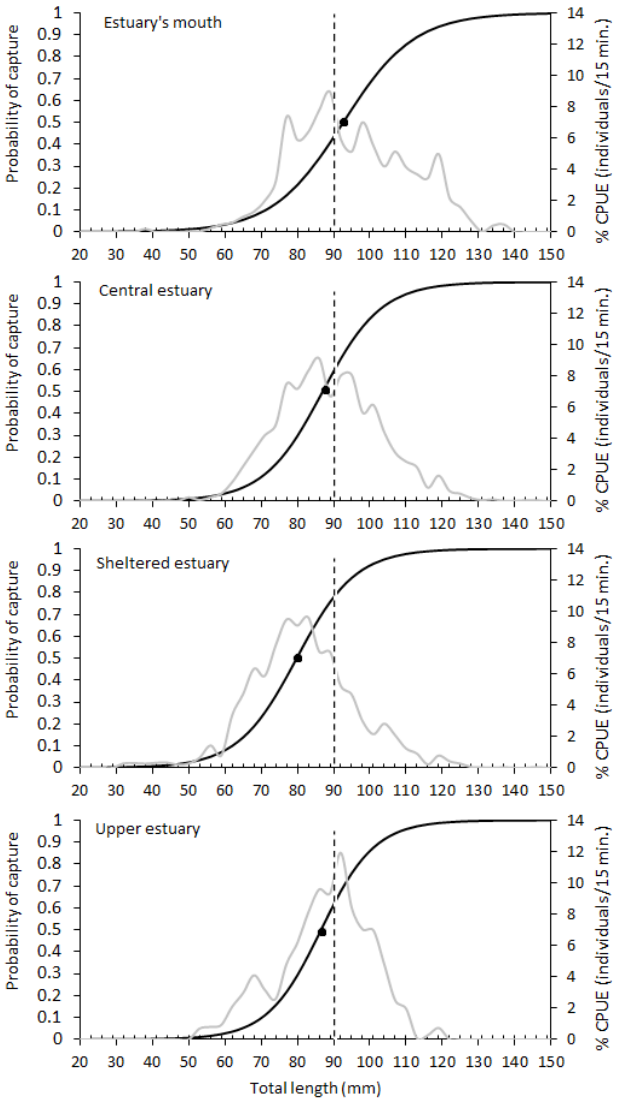

Figure 5. Probability of capture (dark line), where the point marks the size of the first capture (P50%), and CPUE percentage (light line) by size class of the pink shrimp captured with artisanal trawling in the Patos Lagoon estuary by region. The dashed line represents the shrimp at 90 mm TL.

A statistically significant difference between the mean salinities over the three years was found ($p = 0.0000$) using the Kruskal-Wallis test. The 2012 salinity was different from those of 2011 and 2013 ($p = 0.0000$ for both), and 2011 was similar to 2013 ($p = 1.000$). The salinity in 2012 was higher in every month relative to the other years (see Fig. 7). Additionally, during the period from May to September, the salinity declined in both 2011 and 2013. This pattern did not occur during 2012, which displayed a peak of salinity between June and August.

Discussion

The demand by fishermen for a floating fishing season relies on the argument that annual environmental variations occur, mainly related to the salinity of the estuary, which affect shrimp fisheries. Studies of this relationship show that harvests are more abundant in years with higher salinities (Castello & Möller 1978, Kalikoski *et al.* 2006, Möller *et al.* 2009, Pereira & D'Incao 2012). The differences in the proportions of small shrimp between years were not statistically significant for incorporation in the model that explains the variability in the proportion of individuals smaller than 90 mm TL. However, 2013 was the year with the greatest proportion of larger shrimp. The year was not included in the model because the region, depth and month had greater significance in explaining the variability of shrimp size than the year itself. Salinity was not statistically significant therefore was not included in the model,. This differs to that observed by Noleto-Filho (2014) who found that the number of cohorts and modes correlated with salinity indicating the importance of this variable to the shrimp recruitment on the estuary. Therefore, as in 2012, the salinity remained high throughout the year, and the estuary conditions were

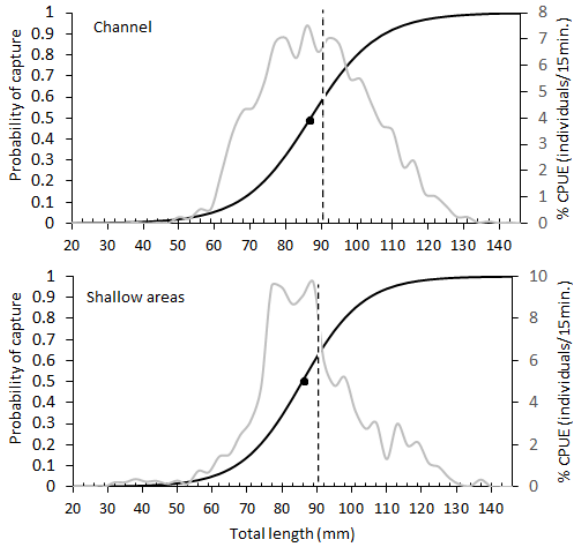

Figure 6. Probability of capture (dark line), where the point marks the size of the first capture (P50%), and CPUE percentage (light line) by size class of the pink shrimp captured with artisanal trawling in the Patos Lagoon estuary by depth. The dashed line represents the shrimp at 90 mm TL.

positive for the entry of larvae in earlier months than the other years. By entering early, the shrimp are afforded more time to grow so that they can reach higher sizes over the fishing season.

The data allowed us to observe that there was a variability in the size structure of the shrimp population according to the month. The post-larvae entrance occurs mainly between September and November, and it takes around four to five months to grow until 70-80 mm of total length, when they start the migration processes back to the sea (D'Incao 1984, 1991). It was expected that smaller shrimps should be caught in the early fishing season (December and January). However, January presented a non-standard pattern displaying mainly larger shrimp sizes. D'Incao (1991) suggest that the post larvae penetration can also occurs, in a less degree, during all year, and that some individuals can remain on the estuary until 10 months old.

Table II. Result of the selected model (cbind (<90 mm TL, >90 mm TL) ~ month+region+depth; family = quasi-binomial=(logit)). Significant P values are marked with * when P<0.1 and ** when P<0.05.

Factor	Explanatory variables	Estimated	Standard error	t	P
	Intercept	-0.2406	0.3509	-0.6860	0.4944
Month (considering all years)	December	0.9292	0.5415	1.7160	0.0891*
	January	-0.2608	0.3456	-0.7540	0.4523
	February	0.5522	0.3404	1.6220	0.1078
	March	0.4316	0.3514	1.2280	0.2223
Region	Estuary mouth	-0.6601	0.2950	-2.2380	0.0274**
	Sheltered estuary	0.4373	0.2966	1.4740	0.1435
	Central estuary	0.0221	0.2540	0.0870	0.0930*
Depth	Shallow areas	0.8661	0.2189	3.9560	0.0001**

The presence of shrimps up to 145 mm total length found on this study at December and January is an evidence that this larger shrimps found on the beginning of season are in fact shrimps that remained over the estuary since the last season. This phenomenon is known by fishermen as off-season or "safrinha". At the opening of the fishing season, when fyke-nets nets are allowed, the effort is intensified, which shows that the fishing effort should act to select the size of individuals in the population. The number of individuals per age decreases according to three factors: natural mortality, fishing mortality and migration (D'Incao 1983). Therefore, a greater capture effort prevents the shrimp reach older ages, decreasing its size capture (D'Incao 1984). The effect of fishing on the population of shrimp in the Patos Lagoon is intense, as few or nearly no individuals return to the sea (D'Incao 1990). Therefore, the periods when shrimp are able to return to the ocean are the months of January and December, which is allowed by reduced fishing efforts. However, it is very important to note that although shrimp sizes are larger during the off-season period, and environmental variations can anticipate their growth, individuals were captured with less than 90 mm TL in higher percentages than those permitted by law (MMA/SEAP 2004). Therefore, an early release of the fisheries would not be possible. Fishermen also argued that trawl nets only catch larger shrimp when used in channel areas (Kalikoski *et al.* 2006). Despite our results corroborating this statement to some extent, it is important to note that the proportion of small individuals in the channel was high.

Table III. Tukey test result for each factor related to the model (cbind (<90 mm TL, >90 mm TL) ~ month+region+depth; family = quasi-binomial(logit)). Significant P values are marked with * when P<0.1 and ** when P<0.05.

Factor	Explanatory variables	Estimated	Standard error	Z	P
Region	Estuary mouth - Upper estuary	-0.660	0.295	-2.238	0.110
	Sheltered estuary - Upper estuary	0.437	0.297	1.474	0.446
	Central estuary - Upper estuary	0.022	0.254	0.087	1.000
	Sheltered estuary - Estuary's mouth	1.097	0.219	5.005	<0.001*
	Central estuary - Estuary's mouth	0.682	0.216	3.162	0.0081*
	Central estuary - Sheltered estuary	-0.415	0.222	-1.873	0.234
Month (considering all years)	December – April	0.929	0.542	1.716	0.397
	January – April	-0.261	0.346	-0.754	0.937
	February – April	0.552	0.340	1.622	0.455
	March – April	0.432	0.351	1.228	0.714
	January – December	-1.190	0.469	-2.540	0.0721*
	February - December	-0.377	0.461	-0.818	0.917
	March – December	-0.498	0.461	-1.080	0.800
	January – February	-0.813	0.196	-4.154	< 0.001**
	March – February	-0.121	0.194	-0.622	0.968
	March – January	0.692	0.193	3.580	0.0026**
Depth	Shallow areas - Channel	0.866	0.219	3.956	< 0.001**

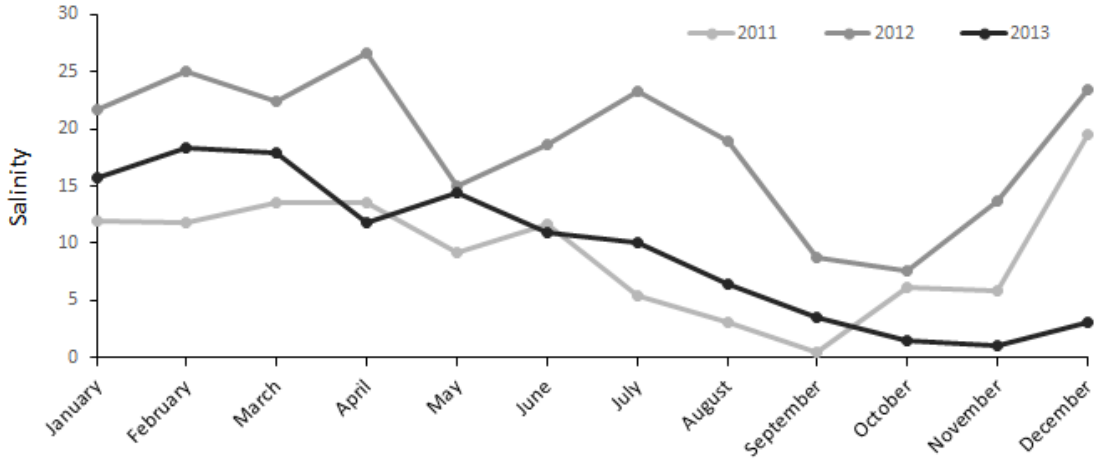

Figure 7. Monthly variation in the mean salinity of the Patos Lagoon estuary by years.

Fishermen were free to choose the fishing spots, and not only channel areas were chosen. Shrimp were repeatedly captured in shallow areas, such as the surroundings of Marinheiros Island. This region is mainly characterized by shallow areas, with the greatest depths observed parallel to the city of Rio Grande (Souza *et al.* 2008). The capture of small-sized shrimp near Marinheiros Island corroborated the nursery function of this region, as discussed by other authors (Ruas *et al.* 2014). Penaeids remain within estuaries during part of their life cycle and prefer to settle on shallow and calm regions, such as small inlets, migrating to open areas as they grow (Vance *et al.* 1998, Adnan *et al.* 2002). In those areas of the Patos Lagoon estuary, the shrimp were larger, especially in the lower estuary region. This area is characterized by a narrow, long channel, typical of strangled lagoons, which

connects the estuary to the sea. As the shrimp grow to the age at which they migrate to the sea, they must pass through this channel, which explains the high catches of larger shrimp in this region. However, small shrimp were also captured in this location, and the prohibition based on the capture percentage by the legislation was not fulfilled. All areas showed higher percentages of smaller shrimp (< 90 mm TL) than those tolerated.

The percentage of shrimp smaller than 90 mm TL captured with fyke-nets nets in the estuary of Patos Lagoon has been studied, and values greater than those permitted by law were registered, with seasonal variations (Almeida & D'Incao 1999, Ruas *et al.* 2011). Almeida & D'Incao (1999) observed percentages between 40% and 48% during one fishing season in Saco da Mangueira, a nearby inlet at the channel of the estuary mouth. Furthermore, these same authors observed a decreasing variation between 85% at the beginning of the fishing season and 23% at the end of the season in Saco do Arraial, a shallow area near Marinheiros Island. Ruas *et al.* (2011) analyzed only Saco do Arraial and found 67.7% of small shrimp at the opening of the season. They also observed a decreasing tendency in that percentage in March and early April, when it increased (up to 98% of small shrimp) and decreased again at the end of the fishing season (36.4% in May). The percentage of small shrimp caught with fyke-nets nets was often higher than those caught while trawling. These differences may reflect the study area because the use of fyke-nets is restricted to shallow areas of the estuary. The model generated to explain the variability of the percentage of small shrimp in the estuary incorporated the area as a significant factor, and the region near Marinheiros Island, also used to evaluate fisheries with fyke-nets nets, showed the highest percentage of smaller shrimp captured. Furthermore, it must be considered that both that fishermen that use fyke-nets nets have techniques to decrease the selectivity of the nets, such as confection of nets with smaller mesh sizes than those allowed, or the use of overlapping meshes in baggers and rings with diameters smaller than usual (Ruas et al. 2011). The monthly variability was also different between the two fishing gears. It is possible that because larger shrimp prefer open regions of the estuary, in particular the estuary mouth, and fyke-nets are used only in shallow areas, they are not good samplers of larger shrimp during the off-season.

The pink shrimp is in the list of overexploited or threatened by overexploitation species, according to Normative Instruction No. 5 (MMA 2004). Several studies have indicated that yields of this species have decreased over the recent years in Southeast and Southern Brazil (Valentini *et al.* 1991, D'Incao *et al.* 2002, Leite & Pretere 2006, Valentini *et al.* 2012). The data presented in this work show that otter trawls are able to capture large amounts of shrimp in smaller sizes than those allowed by law. D'Incao *et al.* (2002) showed that the negative effect of high fishing efforts within the estuary prevented the recruitment of shrimp to the adult stock, which significantly contributed to the maintenance of low yields of industrial fisheries. Therefore, it is important to maintain the fishing seasons based on a fixed schedule to allow part of the stock to be replenished and also to reinforce the fiscalization on number of nets/fishermen.

The data analyzed in this study do not show compliance with the legislation regarding minimal sizes of the shrimp caught in the Patos Lagoon estuary. The captures in shallow inlets were more likely to contain smaller shrimp and, therefore, to require greater supervision. It does not seem right that the premise for the release of this fishing gear is only based on the sizes of the captured shrimp. However, if there is an approval for this demand, it should be applied with certain cautions. The shrimp should be measured along the entire estuary because there is variability in the size structure in the different regions of the estuary. Studies demonstrated that using otter trawls to catch shrimp in tropical environments produced an average of 10 kg of by-catch for each kilogram of the target species (EJF 2003). Thus, the potential impact of the trawl on the ecosystem should also be taken into consideration.

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