GROWTH AND MORTALITIES OF THE PINK-SHRIMP *Farfantepenaeus brasiliensis* LATREILLE, 1970 AND *F. paulensis* PÉREZ-FARFANTE 1967 IN SOUTHEAST BRAZIL

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ABSTRACT

From July, 1999 until July, 2001 data from the pink-shrimp *Farfantepenaeus brasiliensis* Latreille, 1970 and *F. paulensis* Pérez-Farfante, 1967 fishery were collected from trawling by the fishing fleet based in Santos/Guarujá-SP. Growth and mortalities of these species were studied. *F. brasiliensis* and *F. paulensis* have longevity of 2 years and growth estimates of $L_\infty = 29.0$ cm and $k = 1.24$ year^{-1} for *F. brasiliensis* and $L_\infty = 27.5$ cm and $k = 1.34$ year^{-1} for *F. paulensis*. Females reach bigger lengths than males in both species. Natural mortalities (M) were 1.80 and 1.90 year^{-1} and fishing mortalities (F) were 4.7 and 6.8 year^{-1} for *F. brasiliensis* and *F. paulensis*, respectively. Survival rates are S = 0.15% and 0.02% for *F. brasiliensis* and *F. paulensis*, respectively, which are usually low values for shrimps.

Keywords: tropical marine fishery, pink-shrimp, *Farfantepenaeus*, growth, mortalities, Brazil.

RESUMO

Crescimento e mortalidades do camarão-rosa *Farfantepenaeus brasiliensis* Latreille, 1970 e *F. paulensis* Pérez-Farfante, 1967 no Sudeste do Brasil

De Julho de 1999 a Julho de 2001, foram coletados dados das pescarias comerciais do camarão-rosa *Farfantepenaeus brasiliensis* Latreille, 1970 *e F. paulensis* Pérez-Farfante, 1967, relativos à frota pesqueira de arrasto, sediada em Santos (SP). Estimativas dos parâmetros de crescimento e de mortalidades foram calculadas. *Farafantepenaeus brasiliensis* e *F. paulensis* são espécies de crescimento rápido e vida curta, com longevidade de 2 anos ($L_\infty = 29{,}0$ cm e $k = 1{,}24$ ano^{-1} para *F. brasiliensis;* $L_\infty = 27{,}5$ cm e $k = 1{,}34$ ano^{-1} para *F. paulensis*). As fêmeas atingem tamanhos maiores que os machos para ambas espécies. As mortalidades naturais foram estimadas em M = 1,80 ano^{-1} e 1,90 ano^{-1} e as mortalidades por pesca F = 4,7 ano^{-1} e 6,8 ano^{-1} para *F. brasiliensis* e *F. paulensis*, respectivamente. As taxas de sobrevivência foram calculadas em S = 0,15% para *F. brasilensis e S* = 0,02% para *F. paulensis*, valores usualmente baixos para camarões.

Palavras-chave: pescarias marinhas industriais tropicais, camarão-rosa, *Farfantepenaeus,* crescimento, mortalidades, Brasil.

INTRODUCTION

The shrimp fishery history

Exploiting shrimps from the superfamily Penaeoidea is an old and widespread activity in many sub-tropical and tropical areas of the world, especially in coastal areas of various countries (Garcia & Le Reste, 1986). Starting in the 1950s, shrimp exploitation in SE Brazil has increased dramatically due to the development of a specialized industrial fishery. At the end of the 1970s, the international market became highly favorable in terms of commercializing this resource, because of its high prices due to an increased demand from rich countries. As a consequence of this increase, nearly all shrimp stocks in the world are now highly exploited, and many species can even be considered as being over-exploited. There is a paucity of basic knowledge concerning population dynamics of the most exploited species, so that any effort towards a rational exploitation of the stocks is a difficult task (Garcia & Le Reste, 1986; Isaac *et al.,* 1992).

The shrimp fishing production in Brazil occupies the 12th place in the world, and 6th place in the production of shrimps of the Penaeidae family (FAO, 1998). In 1984 and 1985, shrimps represented about 6% in weight and approximately 24% of the economic value of the total fishing production in the Southeastern and South regions (Valentini *et al.*, 1991). In the data set about pink-shrimps (*F. brasiliensis* and *F. paulensis*) in the Southeastern and South regions of Brazil, from 1965 to 1999 the maximum total attained 16,028 t in 1972 and the minimum in 1998 with 2,008 t. The total production of the pink-shrimp increased until 1972 decreasing afterwards with peaks in 1979 (12,780 t) and 1985 (12,511 t), reaching extremely low values in 1994, 1998 and 1999 (2,100, 2,008 and 2,207 t respectively) (Valentini *et al.*, 1991; D'Incao *et al.*, 2002).

Nowadays, the exploitation of pink-shrimps (*Farfantepenaeus brasiliensis* e *F. paulensis*) in South and Southeast Brazil is controlled by the Brazilian Environmental Agency (IBAMA), with nearly 400 trawlers being officially allowed to exploit this resource. These trawlers have a wooden hull, averaging 18.5 m length, 55 t gross tonnages and 246 HP. In southeast Brazil, the state of São Paulo fishing fleet represents 59.0% of all the trawlers, followed by those from Santa Catarina (20%), Rio de Janeiro (18%), Espírito Santo (3%) and Rio Grande do Sul (0.4%) states (IBAMA, 1997).

Biology of the species

Farfantepenaeus brasiliensis Latreille, 1970, is widely distributed, ranging from Cape Hatteras (North Carolina, USA) down to Rio Grande do Sul (South Brazil). This species is most abundant in Cabo Frio (RJ) and in Santos and Cananéia (SP) (Zenger Jr. & Agnes, 1977). *Farfantepenaeus paulensis* Pérez-Farfante, 1967, has a more restricted distribution, ranging from Ilhéus (BA) to northeastern Argentina. On the continental shelf, two areas of high abundance were ecognized: one in Santa Catarina and the other between Santos and São Sebastião Island, state of São Paulo. In Rio Grande do Sul, however, the fishery is restricted to juveniles and sub-adults in the interior of Patos lagoon (D'Incao, 1995; Zenger Jr. & Agnes, 1977).

Both species have the same characteristic life cycles as the Penaeoidea superfamily. Reproduction occurs in the ocean, on the continental shelf at depths between 30 to 100 m. The eggs are benthonic, the larval phases and the first post-larvae are planktonic and oceanic. From the 6th sub-stage of post-larvae the shrimps penetrate in estuarine areas, of lower depths and higher temperatures and start to have benthonic habits. In these areas, the post-larvae become juveniles and pre-adults and start to be exploited by the coastal/artisanal fishing fleet. They complete their life cycle when these juveniles and pre-adults migrate to the ocean to finish developing and reproducing and joining the adult stock (Iwai, 1973; Valentini *et al.*, 1991; Isaac *et al.*, 1992).

The aim of this study was to investigate growth and mortality rates by sex using a length frequency analysis for the two species of pink-shrimp *Farfantepenaeus brasiliensis* and *Farfantepenaeus paulensis* in order to give basic information for further stock management.

MATERIAL AND METHODS

From June, 1999 to June, 2001, with the exceptions of March/April, 2000 and March to May in 2001, the ban period, length measurements, as well as fishery data, were obtained in the main fishery terminals in the municipality of Santos. This city is located on the southern coast of the state São

Paulo, and has the highest number of landings from the industrial fishery of the pink-shrimp in the south and southeast regions of Brazil. This is mostly due to the fact that the trawlers from the state of São Paulo are the only ones that still maintain the pink-shrimp as their target species, whereas the fleets from other States definitely operate a multispecific capture (Perez *et al.,* 2001 unpublished report; D´Incao *et al.*, 2002).

In 76 samples collected during the period, a total of 6,861 pink shrimps from both species were individually processed in order to obtain data on the total (Lt) and carapace (Lc) length, in millimeters, and total weight (Wt), in grams, observing the sex and visually assessing the female maturity stage based on size, color and form of gonads for both species (Neiva *et al.*, 1971). The differentiation between the two species was carried out by observing that *F. brasiliensis* has a rounded spot on the 3^{rd} and 4^{th} tergo-lateral plates in the abdomen (Pérez-Farfante, 1988). The total length was measure with a special shrimp-ruler, graded in millimeters, as the distance from the rostral extremity to the telson extremity. The carapace length was measured with a digital caliper (0.01 mm) from the post-orbital angle to the dorsal posterior margin of the carapace (Isaac *et al.,* 1992; Ruffino, 1991). The weight was quantified with a precision (0.01 g) balance. Length measurements were grouped in size classes (mm) and the monthly frequencies per class were calculated. The sex was determined by the presence of a petasma or thelycum for males and females, respectively.

Biometric relationships between the total weight (Wt) and total length (Lt), for both sexes during 1999/2001, were calculated for both species on a logarithmic scale. The relationship between length calculated in arithmetic scale. All regressions between sexes were compared using a linear regression comparison test. The growth coefficient "b" of Wt/Lt Relationship was compared with 3 (isometric growth) using a "t" test (Snedecor & Cochran, 1967; Zar, 1996).

Length frequency data were analyzed using the software package FiSAT (FAO/ICLARM Stock Assessment Tools), which is part of the analytical tools of the programs LFSA and COMPLEAT ELEFAN (Gayanilo *et al.*, 1994; Sparre & Venema, 1997). Growth data for both species were analyzed, jointly or separately, using a modal progression applied to the length frequency distributions. The von Bertalanffy growth function was used as a growth model (von Bertalanffy, 1938).

The parameters of the growth curve (of von Bertalanffy) were estimated according to the following methods: ELEFAN-I (Pauly & David, 1981), to estimate the parameters L_∞ and k from the von Bertalanffy growth equation; Powell-Wetherall (Powell, 1979), which use the length frequency data to estimate L_∞ and Z/K, and Bhattacharya (1967) to identify the mean length per cohort, together with the Gulland and Holt method (Gulland & Holt, 1959) and the non-linear iterative method (Allen, 1966) for estimates of L_∞, k e t_0. The methods used in this study to estimate the growth parameters showed a certain degree of subjectivity when being carried out. Among all of the obtained estimates from the different methods, we opted for the Elefan-I values as the most appropriate, due to the fit index (Rn) that reduces the degree of subjectivity of the estimates. Thus, the values obtained through this program were used in all of the subsequent models that were required as input data values of the growth parameters.

Seven methods were used to estimate the total mortality rate (Z): Hoening´s empirical method (1984 *apud* Sparre & Venema, 1997), which related the maximum individual longevity to its mortality; the methods of Beverton & Holt (1956), Ault & Ehrhardt (1991) and Ssentongo & Larkin (1973), which calculate mortality from the mean length when captured; Powell-Wetherall´s method (Powell, 1979) to estimate Z/k; Pauly´s method of a catch curve (1983) and Jones & van Zalinge´s method (1981), carried out by FiSAT. The methods used in this study to estimate total mortality showed similar values and then a mean value of the methods was calculated for the two species.

The natural mortality rate (M) was estimated by the Pauly empirical (1980) formula, which relates M to k, L_∞ and the temperature using a multiple regression analysis. The mortality rate per fishery was obtained by the formula: F = Z–M.

RESULTS

Biometrical relationships

The minimum and maximum total lengths (cm) found in the industrial fishery were 7.9 and 21.9 for males and 8.7 and 26.0 for females of

F. brasiliensis; 8.9 and 18.0 (males) and 9.1 and 23.6 (females) for *F. paulensis*. Biometrical relationships between the total weight (Wt) and total length (Lt), and between the Lt and carapace length (Lc) for both sexes during 1999/2001 are presented in Figs 1a and 1b. The regressions (WtxLt), in log-log scale were compared using a test for linear regression comparisons (Snedecor & Cochran, 1967; Zar, 1996), were significantly different ($p < 0.01$) between sexes for both species, a rather expected result as the sample sizes are so large.

The growth coefficient (b) of the Wt/Lt relationship was lower than 3 for males and greater for females of both species ("t" test, $p < 0.01$), indicating a negative and positive allometric growth for males and females respectively (Fig. 1a).

Growth

Growth studies of *F. brasiliensis* and *F. paulensis* were based on the length frequency distributions. The species were analyzed separately by sex, and later, the data for males and females were grouped for each species. This procedure was adopted because, although we could suppose a differentiated growth between the sexes, we needed to obtain mean values for the populations of the two species and for the stock as a whole, since the trawler fleet cannot accomplish the selective capture of the two resources.

Notwithstanding evidence in the literature regarding the existence of seasonal variations in growth (Garcia & Le Reste, 1986), the parameters WP (winter point, which determines the period of the year when growth is slower) and C (a factor that expresses the amplitude of the oscillations), which define the seasonal oscillation in the growth curve, were fixed at zero, since we did not have information on the period and the causes of this oscillation.

From the data on length frequency, it was clear that the cohort recruited to the stock in May came from the December spawning of *F. brasiliensis* and November for *F. paulensis*. These months presented a higher number of mature females in landings from July, 1999 until July, 2001 from trawling by a fishing fleet based in Santos/Guarujá-SP (Leite Jr., 2001; Leite Jr. & Petrere Jr., submitted). Thus, the growth curve was adjusted going through the modal groups that represented these cohorts.

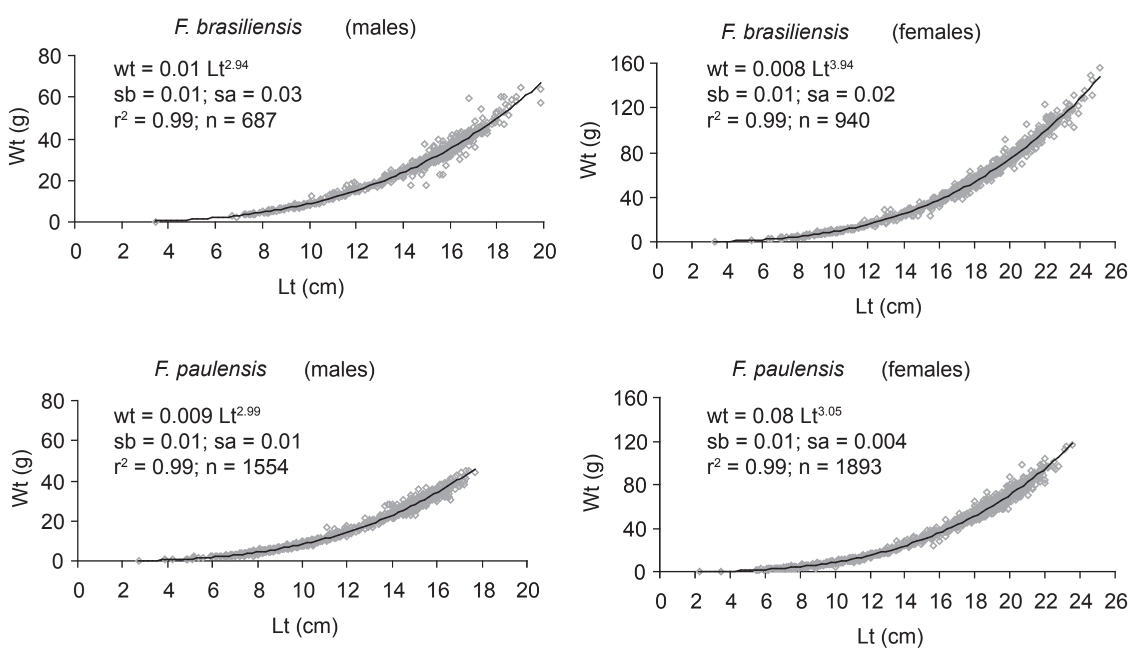


Fig. 1a — Total weight (Wt)/Total length (Lt) relationship for *Farfantepenaeus brasiliensis* and *F. paulensis* separated by sexes from June/1999 to June/2001.

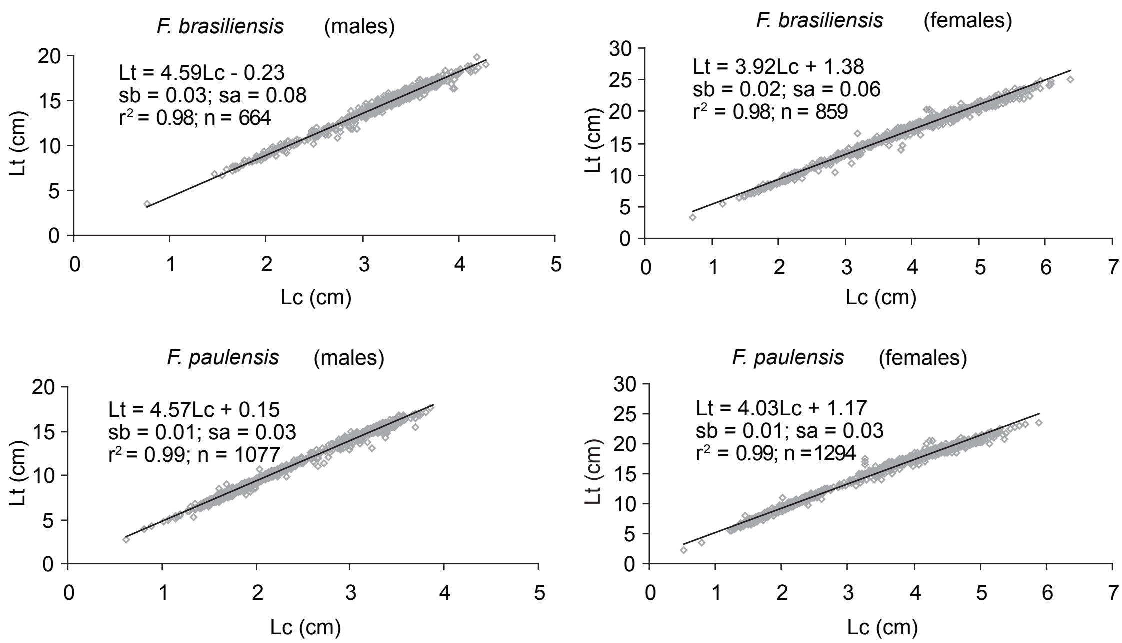


Fig. 1b — Total length (Lt)/Carapace length (Lc) relationship for *Farfantepenaeus brasiliensis* and *F. paulensis* separated by sexes from June/1999 to June/2001.

Figs 2a and 2b show the restructured length frequencies and the results of the best fits found by Elefan-I (Pauly & David, 1981), for data of males, females and combined sexes of both species. As expected, the asymptotic length ($L\infty$) of the females was always larger than that of the males, a common pattern for the species of the family Penaeidae (Garcia & Le Reste, 1986). The values of the growth coefficient (k) were: 0.84 $year^{-1}$ for males, 0.9 $year^{-1}$ for females and 1.24 $year^{-1}$ for combined sexes for *F. brasiliensis*; and 0.83 $year^{-1}$ for males, 1.10 $year^{-1}$ for females and 1.34 $year^{-1}$ for combined sexes for *F. paulensis* (Table 1).

Total mortality rate (Z)

Hoenig empirical method

This method correlates the species longevity with its mortality (Sparre & Venema, 1997). Although the authors did not include crustacean data in their empirical equation, this formula was used with the aim of comparing the results with those of other methods. Perhaps because of this fact, Z values obtained by this method may be sub-estimated (Table 2) and, thus were not included in the calculation of the mean Z for the species.

Methods based on the mean length at capture

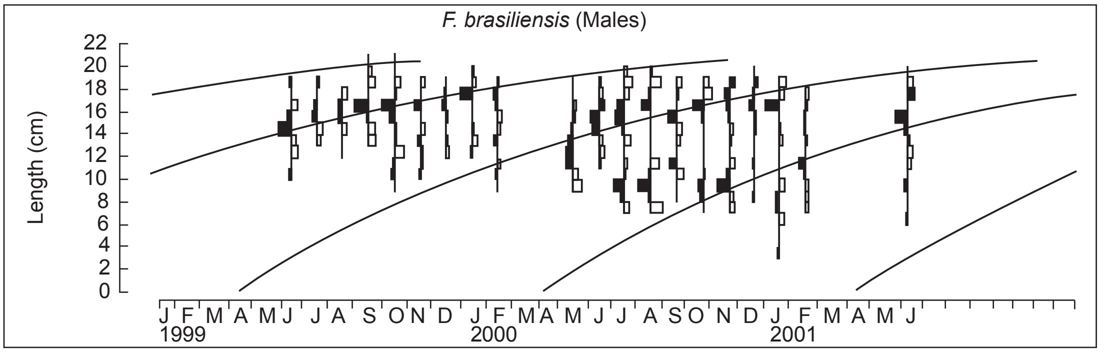
Three methods estimated Z from the mean catch length: Beverton & Holt (1956), Ault & Ehrhardt (1991) and Ssentongo & Larkin (1973). Z values obtained from these methods are presented in Table 2.

Powell-Wetherall method

This method gives an estimate of Z/K (Powell 1979). The correspondent Z values for the k values obtained by Elefan-I are presented in Table 2.

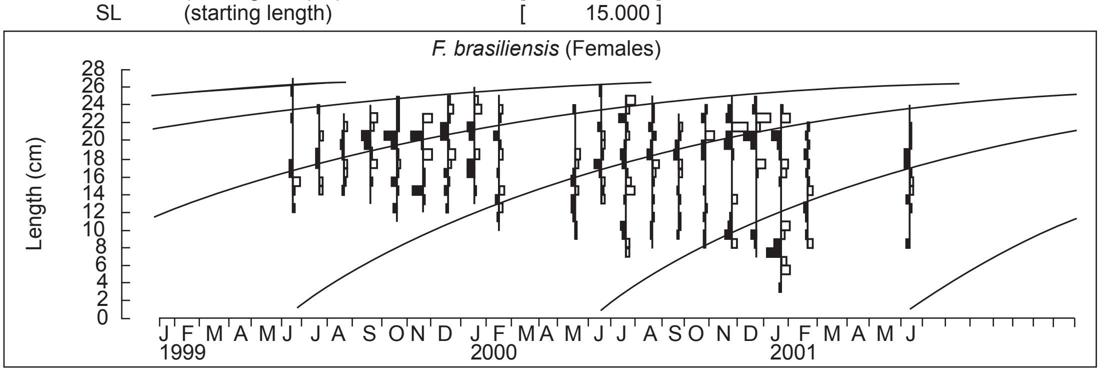
Catch curve method

The catch curve is a graphical representation of the logarithm of the number of survivors of an age class (or of length) compared to the age. The slope of the straight line which links the descending points of the catch curve, with a changing sign, is an estimate of Z (Table 2) (Pauly, 1983). The probabilities of the capture of the classes corresponding to the ascending arm of the catch curve were also estimated. It was observed that in all



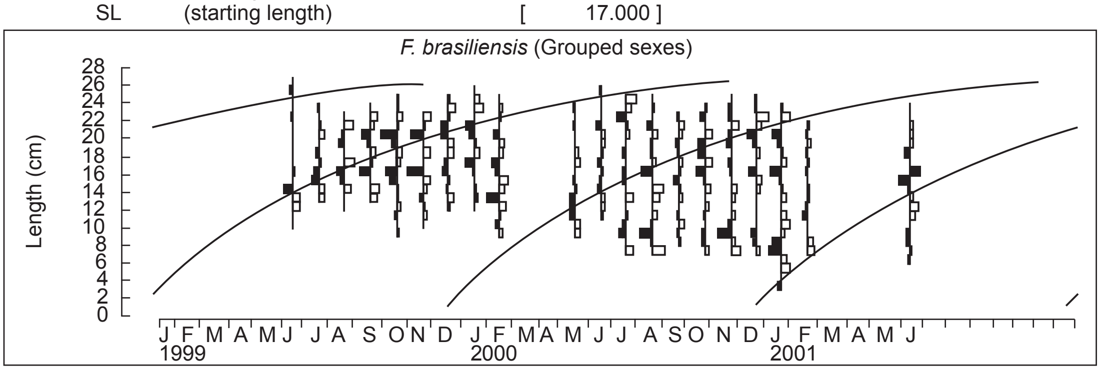
L∞	(asymptotic length)	[23.00]
K	(growth constant)	[0.840]
C	(amplitude)	[0.000]
WP	(winter point)	[0.000]
SS	(starting sample)	[2]
SL	(starting length)	[15.000]

Computed Rn = 0.268



L∞	(asymptotic length)	[28.00]
K	(growth constant)	[0.900]
C	(amplitude)	[0.000]
WP	(winter point)	[0.000]
SS	(starting sample)	[1]
SL	(starting length)	[17.000]

Computed Rn = 0.217



L∞	(asymptotic length)	[29.00]
K	(growth constant)	[1.240]
C	(amplitude)	[0.000]
WP	(winter point)	[0.000]
SS	(starting sample)	[1]
SL	(starting length)	[14.000]

Computed Rn = 0.176

Fig. 2a — Restructured length frequency distributions, length growth parameters and fit index (Rn) estimated by ELEFAN-I for *Farfantepenaeus brasiliensis* for the industrial fisheries data.

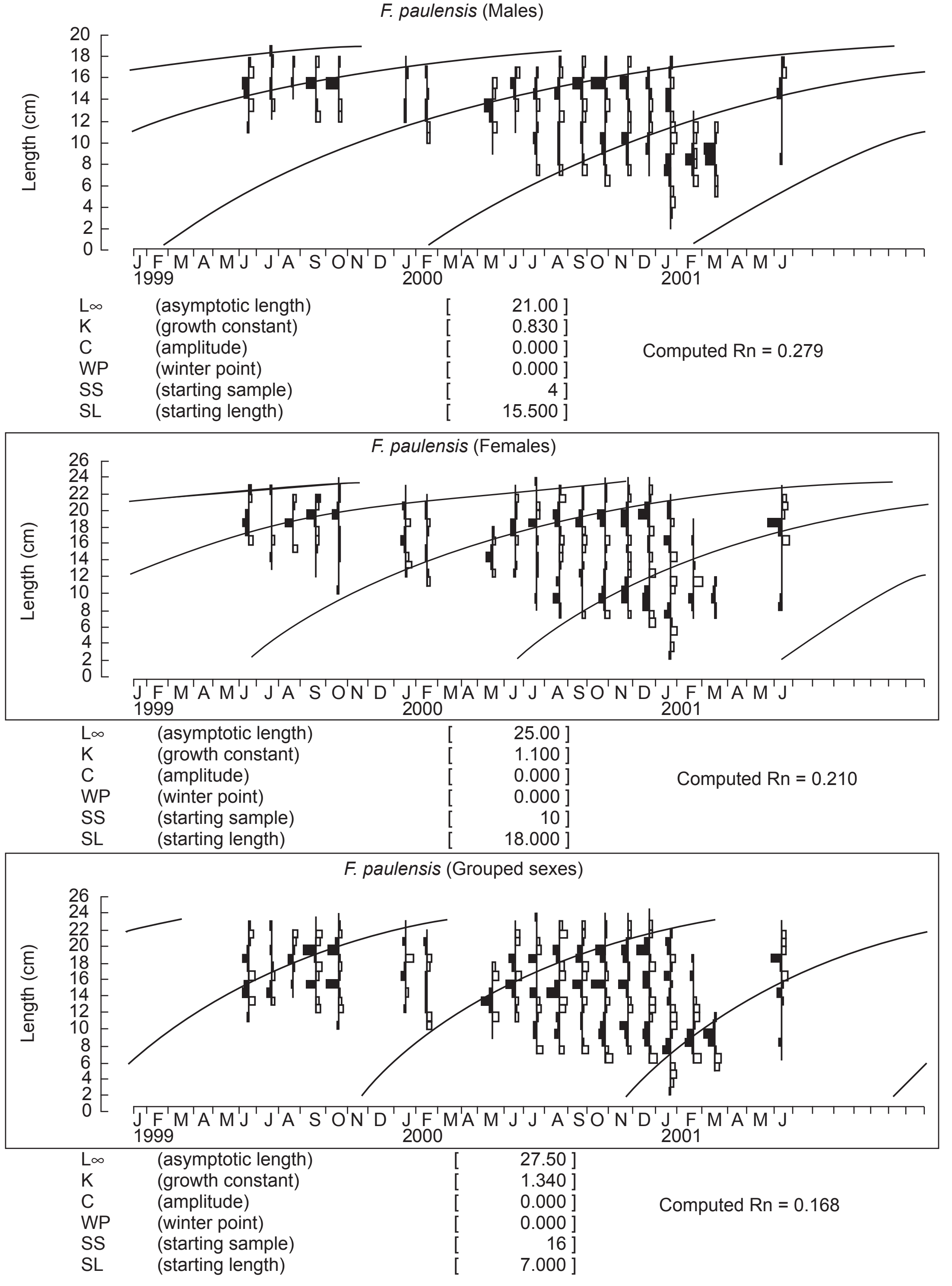


Fig. 2b — Restructured length frequency distributions, length growth parameters and fit index (Rn) estimated by ELEFAN-I for *Farfantepenaeus paulensis* for the industrial fisheries data.

TABLE 1
Growth parameters (L∞ and K) estimates by Elefant-I, for the Pink-Shrimps *(Farfantepenaeus brasiliensis* and *F. paulensis)*.

Species	Data	Sex	L∞ (cm)	K ($year^{-1}$)
F. brasiliensis	Frequency distributions	Males	23.0	0.84
	Frequency distributions	Females	28.0	0.9
	Frequency distributions	Grouped sexes	29.0	1.24
F. paulensis	Frequency distributions	Males	21.0	0.83
	Frequency distributions	Females	25.0	1.1
	Frequency distributions	Grouped sexes	27.5	1.34

cases, the cumulative curves of capture probability increase rapidly from zero to 100%, resembling the knife-edge model, with few length classes.

The Jones and van Zalinge method

This method estimated the total mortality by the cumulative catch curve (Jones & van Zalinge, 1981). The Z values estimated by this method are presented in Table 2.

Natural mortality rate (M)

The Pauly empirical method

The empirical equation of Pauly (1980) relates M to the temperature and growth parameters (L∞ and K). The values calculated in this study used the estimate of L∞ and k obtained by Elefan-I and the mean annual temperature of 20 °C obtained by Castro & Miranda (1998) for the latitudes 23° to 28° 40' (Table 3).

Fishing mortality rate (F)

The fishing mortality rate (F), was estimated by the formula F = Z-M, from mean Z and M values estimated from the above described methods. F values for both species are presented in Table 4. Survival rates (S), in percentage, calculated from the formula $S = (e^{-Z})x100$, varied from 0.02% and 1.4% (Table 4).

DISCUSSION

Biometrical relationships

The maximum total lengths obtained for the industrial fishery, for both species, are similar to those found by Pérez-Farfante (1988) in the Atlantic Ocean. The condition coefficient "b" of the Wt/Lt relationship for males of both species showed negative allometric growth and it was proportionally bigger in length than in weight. The females presented positive allometric growth, indicating higher growth in weight than in length (Tesh, 1968). This result differs from the achieved one by Mello (1973) that found coefficients lower than 3 for males and females of *F. paulensis*, and Zenger Jr. & Agnes (1977) for both species. Many other authors found a negative allometric growth for *F. Brasiliensis* and *F. paulensis* in most of the analyzed cases (Arreguín-Sanches, 1981; Villela *et al.*, 1997; Branco & Verani, 1998a; Albertoni *et al.*, 2003). Branco & Verani (1998b) found coefficients higher than 3 for males and lower for females of *F. brasiliensis*. D'Incao & Calazans (1978) found coefficients higher than 3 in both sexes of *F. paulensis*. The positive allometric growth presented by the females in this study can be associated with the profit in weight due to the gonad development from the collected individuals which were proceeding mainly from adult stock fishing by the industrial fleet in the open sea.

Growth

Peneidae shrimps are individuals of fast and discontinuous growth because of moulting. However, due to the lack of synchronism and high frequency of moult per year, we can use a continuous growth model such as the von Bertalanffy model (von Bertalanffy, 1938; Garcia & Le Reste, 1986).

The growth parameters, for both species, for males and females are numerically different, especially in relation to L∞, which was 23 and 21 cm for males and 28 and 25 cm for females of *F. brasiliensis* and *F. paulensis*, respectively. The estimated L∞ for both species was numerically higher than those estimated by D'Incao (1984) for *F. paulensis*, and by Arreguín-Sánches (1981) and Villela *et al*. (1997), for *F. brasiliensis* and by Mello (1973) for both species (Table 5).

TABLE 2
Total mortality estimated for the Pink- Shrimps (*Farfantepenaeus brasiliensis* and *F. paulensis*) using different methods. Estimated values calculated by Hoenig's method were excluded when calculating means.

Species	Data	Method	Sex	Z ($year^{-1}$)
-	tmax = 2.0 years	Hoenig	-	2.13
-	tmax = 2.5 years	Hoenig	-	1.71
-	tmax = 3.0 years	Hoenig	-	1.43
F. brasiliensis	Catch mean length	Beverton & Holt	males	4.84
	Catch mean length	Ault & Ehrhardt	males	4.83
	Catch mean length	Ssentongo & Larkin	males	5.24
	Length frequency	Powell-Wetherall	males	4.67
	Catch curve	Pauly	males	5.40
	Length frequency	Jones & van Zalinge	males	6.66
	Catch mean length	Beverton & Holt	females	4.07
	Catch mean length	Ault & Ehrhardt	females	4.06
	Catch mean length	Ssentongo & Larkin	females	4.49
	Length frequency	Powell-Wetherall	females	4.34
	Catch curve	Pauly	females	4.06
	Length frequency	Jones & van Zalinge	females	4.61
	Catch mean length	Beverton & Holt	Grouped sexes	6.47
	Catch mean length	Ault & Ehrhardt	Grouped sexes	6.46
	Catch mean length	Ssentongo & Larkin	Grouped sexes	7.06
	Length frequency	Powell-Wetherall	Grouped sexes	6.02
	Catch curve	Pauly	Grouped sexes	7.02
	Length frequency	Jones & van Zalinge	Grouped sexes	5.84
F. paulensis	Catch mean length	Beverton & Holt	males	5.31
	Catch mean length	Ault & Ehrhardt	males	5.30
	Catch mean length	Ssentongo & Larkin	males	5.71
	Length frequency	Powell-Wetherall	males	5.94
	Catch curve	Pauly	males	6.60
	Length frequency	Jones & van Zalinge	males	8.33
	Catch mean length	Beverton & Holt	females	4.81
	Catch mean length	Ault & Ehrhardt	females	4.80
	Catch mean length	Ssentongo & Larkin	females	5.34
	Length frequency	Powell-Wetherall	females	6.21
	Catch curve	Pauly	females	4.81
	Length frequency	Jones & van Zalinge	females	4.43
	Catch mean length	Beverton & Holt	Grouped sexes	8.85
	Catch mean length	Ault & Ehrhardt	Grouped sexes	8.84
	Catch mean length	Ssentongo & Larkin	Grouped sexes	9.49
	Length frequency	Powell-Wetherall	Grouped sexes	7.47
	Catch curve	Pauly	Grouped sexes	9.77
	Length frequency	Jones & van Zalinge	Grouped sexes	7.66
F. brasiliensis	mean		males	5.27
	mean		females	4.27
	mean		grouped sexes	6.48
F. paulensis	mean		males	6.20
	mean		females	5.07
	mean		grouped sexes	8.68
-	Average mean (excluded Hoenig's Method)		-	5.99

TABLE 3
Natural mortality estimated (M), for the Pink-Shrimps (*Farfantepenaeus brasiliensis* and *F. paulensis*) using Pauly empiric method.

Species	Data	Sex	M ($year^{-1}$)
F. brasiliensis	L∞ = 23; K = 0.84; T = 20 °C	Males	1.47
	L∞ = 28; K = 0.9; T = 20 °C	Females	1.45
	L∞ = 29; K = 1.24; T = 20 °C	Grouped sexes	1.78
F. paulensis	L∞ = 21; K = 0.83; T = 20 °C	Males	1.49
	L∞ = 25; K = 1.1; T = 20 °C	Females	1.71
	L∞ = 27.5; K = 1.34; T = 20 °C	Grouped sexes	1.89
F. brasiliensis	Mean	-	1.57
F. paulensis	Mean	-	1.70
-	Average mean	-	1.68

TABLE 4
Estimates of total (Z), natural (M) and fishing (F) mortalities and survival rates (S) for the Pink-Shrimps (*Farfantepenaeus brasiliensis* and *F. paulensis*).

Species	Sex	Z ($year^{-1}$)	M ($year^{-1}$)	F ($year^{-1}$)	S (%)
F. brasiliensis	Males	5.3	1.5	3.8	0.51
	Females	4.3	1.5	2.8	1.40
	Grouped sexes	6.5	1.8	4.7	0.15
F. paulensis	Males	6.2	1.5	4.7	0.20
	Females	5.1	1.7	3.4	0.63
	Grouped sexes	8.7	1.9	6.8	0.02
Average mean	-	6.0	1.7	4.3	0.25

According to D'Incao (1984), the results reported by Mello (1973) for both species in southeast Brazil might be under-estimated, as his sampling period (1965 to 1969) coincided with an increase of the state of São Paulo fishing fleet, and so with an increase in the fishing effort. These observations might be associated to a reduced chance of the species reaching adult age and, thus, to a decrease in the individual lengths when being captured. Data obtained by Villela *et al.* (1997) for *F. brasiliensis*, in Araruama Lagoon/RJ, were lower than those obtained in the present study, owing to the fact that samples were restricted to juvenile individuals. The L∞ estimated by D'Incao (1984) for *F. paulensis* is quite similar to the value obtained in the present study. Numerically the value is lower, perhaps due to the fact that the sampling efforts conducted by the author were restricted to the interior of the Patos lagoon (RS). The L∞ values found by Arreguín-Sánches (1981), for *F. brasiliensis* in the Atlantic coast of Mexico are numerically similar to those obtained in the present study.

The k values had a smaller variation, between 0.83 and 1.67 $year^{-1}$ for the two species, being below the minimum limit of 1.8 $year^{-1}$ considered by Garcia & Le Reste (1986). In comparison with the results obtained by D'Incao (1984) for *F. paulensis*, k values were smaller for males and larger for females. Results obtained by Mello (1973) for both species and by Arreguín-Sánches (1981) for *F. brasiliensis*, showed larger k values for both sexes in the two species. The values of k were inside the interval of values obtained by Villela *et al.* (1997) for *F. brasiliensis* (Table 5). The estimated parameters, for both species,

TABLE 5
Comparison between growth parameters L∞ (cm) and K (year^{-1}) in this study and the estimated from literature in different localities of study, for the Pink-Shrimps (*Farfantepenaeus brasiliensis* and *F. paulensis*).
Values between brackets are the maximum length for the species.

L∞ (cm)						
Species	**Sex**	**Present study (SP)**	**D'Incao (1984) (RS)**	**Mello (1973) (SP)**	**Arreguín-Sánches (1981) (Mexico)**	**Villela *et al.* (1997) (RJ)**
F. brasiliensis	Male	23.0 (21.9)	-	17.6	21.9	-
	Female	28.0 (26.0)	-	20.5	26.6	-
	Grouped sexes	29.0	-	-	-	12.61 a 13.83
F. paulensis	Male	21.0 (18.0)	19.3	16.5	-	-
	Female	25.0 (23.6)	24.8	21.5	-	-
K (year^{-1})						
Species	**Sex**	**Present study (SP)**	**D'Incao (1984) (RS)**	**Mello (1973) (SP)**	**Arreguín-Sánches (1981) (Mexico)**	**Villela *et al.* (1997) (RJ)**
F. brasiliensis	Male	0.84	-	1.62	3.01	-
	Female	0.90	-	2.52	2.05	-
	Grouped sexes	1.24	-	-	3.32	1.2 a 1.7
F. paulensis	Male	0.83	1.25	1.12	-	-
	Female	1.10	1.03	2.40	-	-

for the combined sexes, were very close to the values obtained for females, probably due to the preponderance of females in the samples.

In penaeids, males have lower L∞ and higher k than females (Garcia & Le Reste, 1986; Dall *et al.*, 1990) in this study, growth parameters of males and females of *F. brasiliensis* are compatible with this information. Males of *F. paulensis* presented lower values of L∞ and k than females. According to Pauly *et al.* (1984) the annual k could vary from 0.25 to 2.5 years^{-1} and longevity from 1.5 to 2.5 years in penaeids (Garcia & Le Reste, 1986). The growth parameters estimated in the present study are compatible with published information available for both species.

Mortality

The estimated mean values of Z for both species, 5.3 year^{-1} (males), 4.3 year^{-1} (females) and 6.5 year^{-1} (combined sexes) for *F. brasiliensis* and 6.2 year^{-1} (males), 5.1 year^{-1} (females) and 8.7 year^{1} (combined sexes) for *F. paulensis*, were similar to the estimated values in the literature for heavily exploited stocks. Pauly, Ingles & Neal (1984 *apud* Isaac *et al.*,1992) reported values of 5.43 and 6.71 year^{-1} for males and females of *Litopenaeus setiferus* Pérez-Farfante, 1969 in Texas/USA and 7.07 year^{-1} for *Farfantepenaeus duorarum* Burkenroad, 1939 in Flórida/USA. In a revision of various penaeidean from Africa, Australia and the Gulf of Mexico, Garcia (1985) reported a mean total mortality around 4 years^{-1}. D'Incao (1984) found Z values of 7.80 and 6.84 year^{-1} for males and females of *F. paulensis* in the estuary of Patos Lagoon/RS and Villela *et al.* (1997) found values between 9.22 and 9.44 year^{-1} for *F. brasiliensis* in Araruama Lagoon/RJ.

There are many procedures to calculate the natural mortality rate (M). However, all of these procedures are highly doubtful in their theoretical implications and, in most cases, they just allow an approximate estimate or an intelligent guess (Sparre & Venema, 1997).

The M values obtained in this study were estimated using Pauly´s empirical method (1980). This formulae is derived from data of fish stocks and Pauly´s empirical method was used by Isaac *et al.* (1992), for *Farfantepenaeus subtitilis* Pérez-Farfante, 1967, with the results being similar to those obtained from the regression between the total mortality and effort. Isaac *et al.* (1992) highlight that, although the estimated values obtained from empirical equations should be considered as an approximation of the true M value, these methodologies are widely used in the fishery literature, as more precise methods are not available yet or have unviable applications. Within this context, the values obtained from Pauly´s empirical model (1980) were used in all of the subsequent models that used the natural mortality rate as input data.

Garcia & Le Reste (1986) argued that, due to the high k values, penaeid shrimps would have equally high M values. The mean M values obtained in this study for *F. brasiliensis* and *F. paulensis* were of 1.8 and 1.9 $year^{-1}$, respectively. In Garcia's above mentioned revision (Garcia, 1985), the mean M value was 2.4 $year^{-1}$, ranging from 1.8 to 2.5 $year^{-1}$ for *Farfantepenaeus aztecus* Ives, 1891, 2.2 $year^{-1}$ for *Litopenaeus setiferus* Pérez-Farfante, 1969, 2.5 to 3.0 $year^{-1}$ for *Farfantepenaeus notialis* Pérez-Farfante, 1967, 2.5 $year^{-1}$ for *Fenneropenaeus indicus* Milne Edwards, 1837 and 2.4 $year^{-1}$ for *Melicertus sp.* Rafinesque, 1814 and *Fenneropenaeus merguiensis* De Man, 1888. Estimates of M for *F. paulensis* were 1.56 and 1.32 $year^{-1}$ for males and females, respectively (D'Incao, 1984). Villela *et al.* (1997) found M values between 2.08 and 2.41 $year^{-1}$ for *F. brasiliensis* in Araruama Lagoon/RJ. Notwithstanding the fact that all these values are approximations and subject to long-term seasonal changes, they seem to be coherent and within the same order of magnitude.

The F values for both species, 4.7 $year^{-1}$ for *F. brasiliensis* and 6.8 $year^{-1}$ for *F. paulensis,* were above the mean value (1.6 $year^{-1}$) reported by Garcia (1985) for highly exploited stocks. However, this author used F values, for the calculation of this mean value, ranging from 1.1 $year^{-1}$ to 12.0 $year^{1}$. The values obtained in the present study are within this wide interval. Using Z and M values estimated for *F. paulensis* by D'Incao (1984) for the artisanal fishery restricted to the Patos lagoon/RS, the F values for this species were 6.24 $year^{-1}$ for males and 5.52 $year^{-1}$ for females. These values are higher that those found in the present (4.7 and 3.4 $year^{-1}$ for males and females, respectively) for the industrial fishery in the open sea, as well as higher than the value found by Villela *et al.* (1997) for *F. brasiliensis* in Araruama lagoon/RJ (7 $year^{-1}$).

Natural mortality of small organisms like shrimps is always high and besides this, Penaeid shrimps are heavily exploited on the Brazilian coast and in all the seas of the world. Juveniles were fished in the estuaries and swallow waters by small trawlers and adults in the open sea by an industrial fleet. The estimated parameters of the present study show that pink-shrimps have short life cycles, fast growth, short longevity and high mortality rates and indicate that the fishery effect on the resource is very intense, leading to a low survival rate for both species. Several studies show that the pink-shrimp fishery is at its maximum sustainable yield (D'Incao *et al.,* 2002; Valentini *et al.*, 2001). So, it is necessary to implement administrative procedures in order to preserve the stock, like the immediate reduction in the fishing effort by reducing the fleet size, along with closed seasons and of some fishery areas to assure the recruitment of the species.

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