

Biology of *Isopisthus parvipinnis*: an abundant sciaenid species captured bycatch during sea-bob shrimp fishery in Brazil

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Trawling is the most common method of shrimp harvesting. This technique causes a negative impact on the fauna due to the high bycatch rates and to the animals that are accidentally caught and generally returned to the sea dead. The consequences of this technique and the biological aspects of the involved species are poorly studied, specially in the Brazilian northeast. The objective of this study was to show some aspects of the population biology of *Isopisthus parvipinnis* (Bigtooth corvina) captured as bycatch during sea-bob (*Xiphopenaeus kroyeri*) shrimp fishing in the region of Ilhéus, in the state of Bahia in Brazil. A total of 1290 individuals were caught in a monthly sampling at three different stations, from March, 2003 to February, 2005. The standardized Morisita index of dispersion suggests that this species has a clumped distribution in the studied area. The number of individuals showed a significant variation ($p < 0.0001$) between the seasons, being higher during the winter. The estimated first maturation length (L_{50}) was about 159 mm, and 95% of the captured individuals were below this value. The sexual ratio found was 1.5 males for each female. Concerning to diet, 10 feeding categories were identified, and Decapoda Dendobranchiata was the most important in numeric frequency and occurrence. This fact suggests that *Isopisthus parvipinnis* is a carnivorous species, with a tendency toward crustacean-eating at least in the younger individuals.

A pesca de arrasto é o método mais comum de captura de camarão. Esta técnica causa impactos negativos na fauna demersal devido ao grande número de animais que são capturados acidentalmente e que geralmente são devolvidos mortos ao mar. As conseqüências desta metodologia de pesca e os aspectos biológicos das espécies envolvidas são pouco estudados, especialmente no Nordeste do Brasil. Este estudo tem como objetivo mostrar aspectos biológicos de *Isopisthus parvipinnis* (tortinha) capturada como fauna acompanhante da pesca do camarão sete barbas (*Xiphopenaeus kroyeri*) na região de Ilhéus, no estado da Bahia, Brasil. Um total de 1290 indivíduos foram capturados em coletas mensais, em três pontos de coleta distintos, de março de 2003 a fevereiro de 2005. O índice de dispersão de Morisita padronizado sugere que a espécie, na área analisada, apresenta uma distribuição agregada. O número de indivíduos variou significativamente entre as estações do ano ($p < 0,0001$), sendo maior durante o inverno. O comprimento estimado de primeira maturação (L_{50}) foi de 159 mm, sendo que 95% dos indivíduos capturados estavam abaixo deste valor. A razão sexual encontrada foi de 1,5 machos para cada fêmea. Quanto à dieta, foram identificadas 10 categorias alimentares, sendo que Decapoda Dendobranchiata foi a mais importante em frequência numérica e de ocorrência. Este fato sugere que *Isopisthus parvipinnis* é uma espécie carnívora, com tendência a carcinofagia, ao menos nos indivíduos jovens.

Key words: Biometric relationships, Inner shelf, Brazilian northeast.

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Introduction

Trawling is a very efficient but non-selective method of harvesting aquatic resources, because results in the accidental capture of large quantities of individuals that are sympatric to the target species, which together are called bycatch (Alverson *et al.*, 1994; Perez *et al.*, 2001; Vianna, 2001). It is composed of immature and/or small individuals who are discarded because they have no commercial value. Fish species are generally the most abundant in number of individuals and biomass when compared to other groups, representing almost 70% of the bycatch (Coelho *et al.*, 1986; Haimovici & Mendonça, 1996; Santos, 2000; Branco, 2001; Graça Lopes *et al.*, 2002).

The Sciaenidae family is relatively abundant in this kind of fishery. Some species are found in estuarine regions, and others are strictly freshwater species, but the majority is found in shallow waters of the continental shelf over sand and mud flats or in coral reefs. They constitute one of the most important coastal demersal fishing resources of the Atlantic (Menezes & Figueiredo, 1980; Cervigón *et al.*, 1992).

The species *Isopisthus parvipinnis* (Cuvier, 1830) (Osteichthyes: Sciaenidae) comprises one of the main bycatch elements of *Xiphopenaeus kroyeri* (Heller, 1862) shrimp trawl fisheries in Brazil (Coelho *et al.*, 1986; Paiva-Filho & Schmiegelow, 1986). Popularly known as “*tortinha*,” it has low commercial interest and is generally used as bait. It is distributed from Costa Rica to the south of Brazil, in coastal waters with an average depth of up to 50 meters (Menezes & Figueiredo, 1980; Cervigón *et al.*, 1992; Carpenter, 2002).

Studies on distribution, abundance and population growth of species exploited by fishing allow data to be obtained regarding the effect on non-target resources (Vianna *et al.*, 2000). Furthermore, they can contribute to the formulation of fishery management plans and policies in favor of a better utilization of the catches (Gulland, 1966). Research regarding biological aspects of *I. parvipinnis* has been conducted in the southern (Coelho *et al.*, 1988; Chaves *et al.*, 1998; Chaves *et al.*, 2003) and south-eastern regions (Soares, 1989; Giannini & Paiva-Filho, 1994; Soares & Vazzoler, 2001) of Brazil, but there are no studies on this species in northeastern area. Especially in this region, the continental shelf is very close (about 32 km) (França, 1979), and because of this the low depth trawling is concentrated in few areas, possibly increasing the impacts.

In this context, the main aim of the present study was to provide information on the biology of *I. parvipinnis* on the coast of Ilhéus, Bahia, Brazil, contributing to the broad, current knowledge of this species, and based on this to propose non-fishing alternative periods for the shrimp fisheries.

Material and Methods

The city of Ilhéus is located in the south of the state of Bahia (14°46'S 39°02'W) in Brazil. The main rivers that cross the city are the Almada (Almada sub-basin), Cachoeira, Fundão and Santana (Colônia/Cachoeira sub-basin) (Bahia, 2001). The climate is hot and permanently humid, without a

dry season. The average rainfall is 1716.6 mm/year with an evaporation of 1469.6 mm/year. The average annual temperature is 23.3°C, with a minimum of 19.4°C and a maximum of 28.5°C (Bahia, 2001). The coast of Ilhéus is situated within the trade wind belt of the South Atlantic (NE - E - SE), which is related to a high-pressure cell. Seasonally, this high-pressure cell tends to expand and contract. During the winter, the high-pressure zone covers a vast area over the continent, whereas during the summer it returns to the ocean. On the coastal zone, this seasonal movement controls the position of the Divergence Zone (DZ), between the trade winds *sensu stricto* (SE) and the returning trade winds (NE). During the winter, due to the fact that the DZ is located at approximately 20°S, winds coming from the SE and E arrive at the coast of Ilhéus. Moreover, during this period the winds arising from the SSE, associated with the periodic advance of the Atlantic polar front, reinforce the trade winds from the SE. During the summer, the position changes to approximately 13°S. Therefore, the coast of Ilhéus could be reached by winds arising from the NE and E. These temporal changes in the wind regime cause alterations in the predominant wave fronts of the region (Dominguez & Bittencourt, 1994; Martin *et al.* 1998; Bittencourt *et al.*, 2000).

The continental shelf off the study area shows a reduced

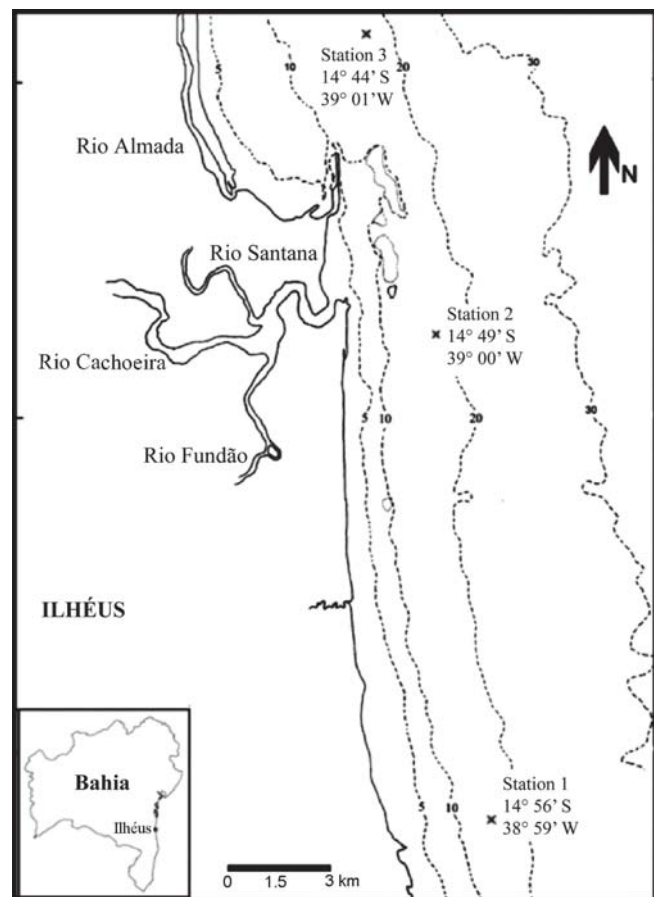


Fig. 1. Map of the studied area (Ilhéus city, Bahia State, Brazil) indicating the sample sites (x) and the isobaths (dashed lines).

width (an average of 18 km), and is characterized by sand and sandy mud in the shallower regions (up to 10 m in depth), followed by mixed muddy sediments that can reach 20m deep. Sand and muddy bio-detritus sediments are predominant close to the rocky bodies and in the continental shelf break. Formation of reefs is present on the shoreline south of the Ilhéus city (Martin *et al.*, 1980; Bittencourt *et al.*, 2000).

Sampling was conducted monthly from March, 2003 to February, 2005 at three stations at a depth of 16 m (Fig. 1). Specimens were caught using a 0.55 x 1.00 m bottom trawl net, with 22 mm stretch mesh in the body and wings and 16 mm bar mesh at the cod end. It was pulled for 30 min using a boat 8 m long and with 20 HP.

Biological material in the field was kept in ice. In the laboratory, samples were stored in a freezer (-20°C) until processing. Fishes were identified according to Menezes & Figueiredo (1980), and total length (mm) and weight (g) was recorded for each specimen. Whenever possible, gonads were weighed and the stage of maturity was macroscopically observed, according to the criteria proposed by Vazzoler (1996): I - immature; II - developing; III - ripe; and IV - post-spawning. The stomachs were removed and preserved in 70% alcohol. Voucher specimens were deposited in the ichthyological collection (ISPA 01) of the Laboratory of Biological Oceanography (Laboratório de Oceanografia Biológica – UESC).

The standardized Morisita index “Ip” was used to study the population distribution pattern in the examined area, which varies from -1.0 to 1.0 with a 95% confidence limit, following the classification: aggregate population distribution pattern ($Ip \geq 0.5$), uniform pattern ($Ip \leq -0.5$) and random pattern ($-0.5 < Ip < 0.5$) (Krebs, 1999).

Variations in the number of individuals between stations and seasons (summer, autumn, winter and spring) were compared using analysis of variance (ANOVA), interaction among variables (stations and seasons) were tested and the values were initially standardized as square root + 0.5 (Zar, 1996).

Average length of first maturity (L_{50}) using a non-linear adjustment, sex ratio and length/weight relationships were estimated for the whole group of data (Zar, 1996).

The stomach contents of 241 individuals caught between May and December of 2004 were analyzed using a stereoscopic microscope. Food items were identified to the lowest possible taxonomic level and the qualitative and quantitative characterization was performed by observing the number and frequency of occurrence of food items, as defined by Hyslop (1980), Fonteles-Filho (1989) and Zavala-Camin (1996). Due to the high degree of digestion, it was not possible to determine weight or volume of food items, which did not allow the calculation of relative importance indexes.

Results

The species *I. parvipinnis* was the most abundant in number of individuals (1290) of all the captured fish species, corresponding to almost 20% of the fish assemblage captured as bycatch.

The standardized Morisita index (“Ip”) was 0.53, indicating an aggregate population distribution pattern (95% confidence level).

Significant differences were observed in the abundance of *I. parvipinnis* throughout the year (Table 1), with the highest average values recorded in the winter (Fig. 2). A total of

Table 1. Analysis of variance (ANOVA) of the number of *I. parvipinnis* individuals in the region of Ilhéus (BA) among stations and seasons of the year and their interactions. V.S: Variance sources, SQ: sum of squares, DF: degrees of freedom, MS: mean squares, F: value of F test. Bold values denote significant values ($p < 0.05$).

V.S	SQ	DF	MS	F	p
Stations	2,297	2	1,148	0.132	0.8764
Seasons	208,400	3	69,467	8.002	0.0002
Seasons * Station	44,214	6	7,369	0.849	0.5386
Error	442,762	51	8,682		

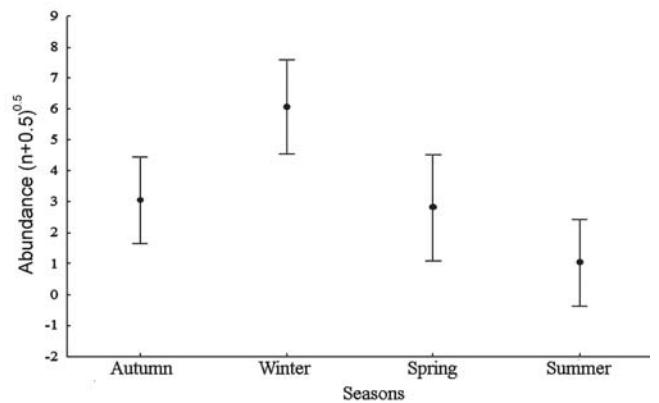


Fig. 2. Adjusted average of number of *Isopisthus parvipinnis* individuals captured over the seasons on coast of Ilhéus, Bahia, Brazil.

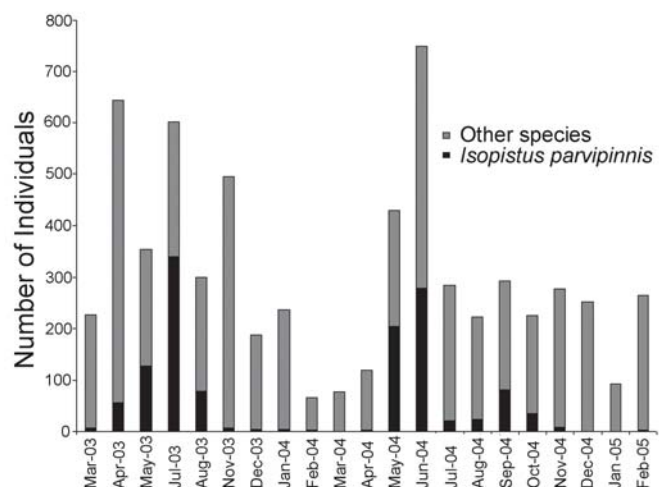


Fig. 3. Total number of *Isopisthus parvipinnis* individuals captured per sampling month along the coast of Ilhéus, Bahia, Brazil.

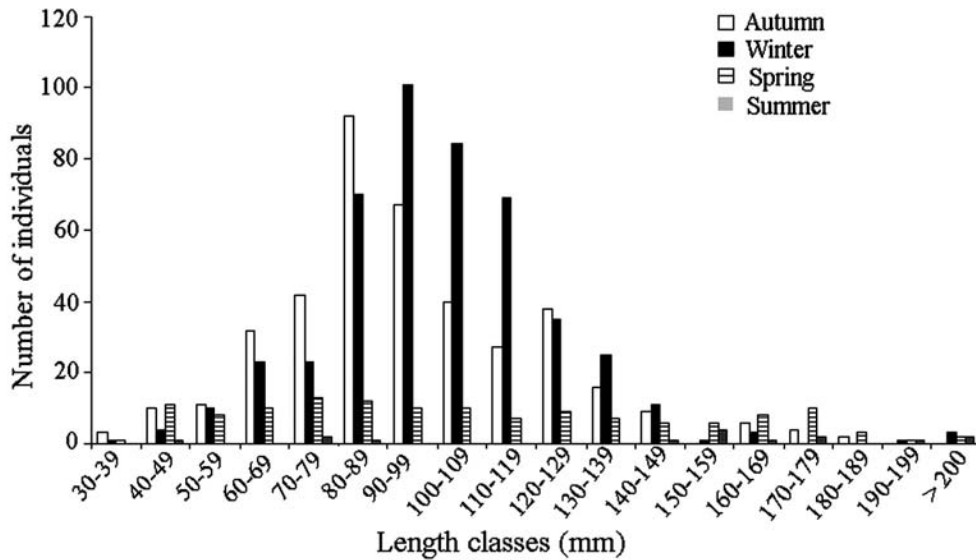


Fig. 4. Number of *Isopisthus parvipinnis* individuals ($n = 990$) per length category across those captured along the coast of Ilhéus, Bahia, Brazil.

1142 individuals (approximately 89% of all the captured specimens) were recorded in autumn and winter. In the summer, only 15 individuals were captured. The months with the highest abundance were May, June and July (end of autumn and beginning of winter), during which the species corresponded to more than 40% of all captured ichthyofauna (Fig. 3). No significant differences were observed in the number of individuals among the three stations or there was no interaction between stations and seasons (Table 1).

Total length of the individuals varied from 30 to 228 mm, with modes of 80 and 90 mm. A seasonal variation was recorded in the relative frequency of size distribution. In the autumn, the mode class was 80 mm and 90 mm in winter,

whereas no length class modes were present in spring or summer (Fig. 4). The highest average length of individuals was recorded in the summer ($145 \text{ mm} \pm 54.1$) and the lowest was noted in autumn ($95 \text{ mm} \pm 25.9$) (Fig. 5). Similarly, this pattern was repeated for average individual weight ($35.0 \text{ g} \pm 28.6$ and $9.0 \text{ g} \pm 8.1$, respectively).

The estimated length of the first maturation (L_{50}) for grouped sexes of *I. parvipinnis* was 159 mm and the length in which all captured individuals were mature (L_{100}) was 220 mm (Fig. 6). Almost 95% of all captured individuals were under the estimated length for first maturation.

Regarding the entire sampling period, the sex ratio in the area was 1.5 males for each female. From the total of 55 adult individuals (representing 5% of total individuals), only 2 females and 11 males showed ripe gonads (stage III). No gonads were observed at post-spawning stage (stage IV). The highest number of adults was captured in the summer (73%) and the lowest was captured in the winter (2%). Immature individuals (stage I) were present throughout the entire sampling period but were more abundant in the winter.

The total length/weight relationship of the samples indicates a negative pattern of allometric growth ($a = 0.00002$, $b = 2.86$ and $r^2 = 0.967$) (Fig. 7).

Of the 241 analyzed stomachs, 19 were empty. A total of 10 food items were identified (Table 2) other than the presence of parasite (Nematode; FO = 1%). Regarding the frequency of occurrence, Decapoda Dendobranchiata and digested organic matter were predominant. Furthermore, Decapoda Dendobranchiata was the most representative category concerning numeric frequency, followed by Teleostei.

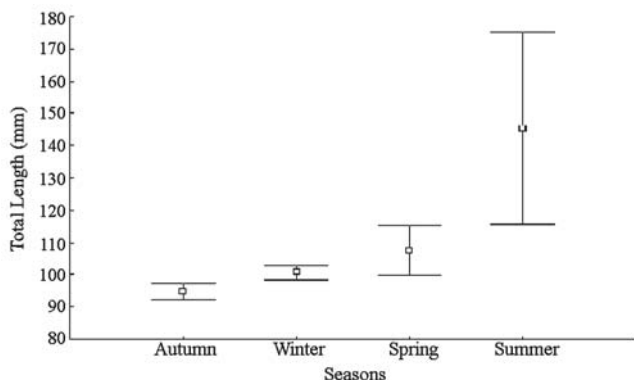


Fig. 5. Average length of *Isopisthus parvipinnis* and confidence interval of 95% ($n = 990$) across seasons of those individuals captured along the coast of Ilhéus, Bahia, Brazil.

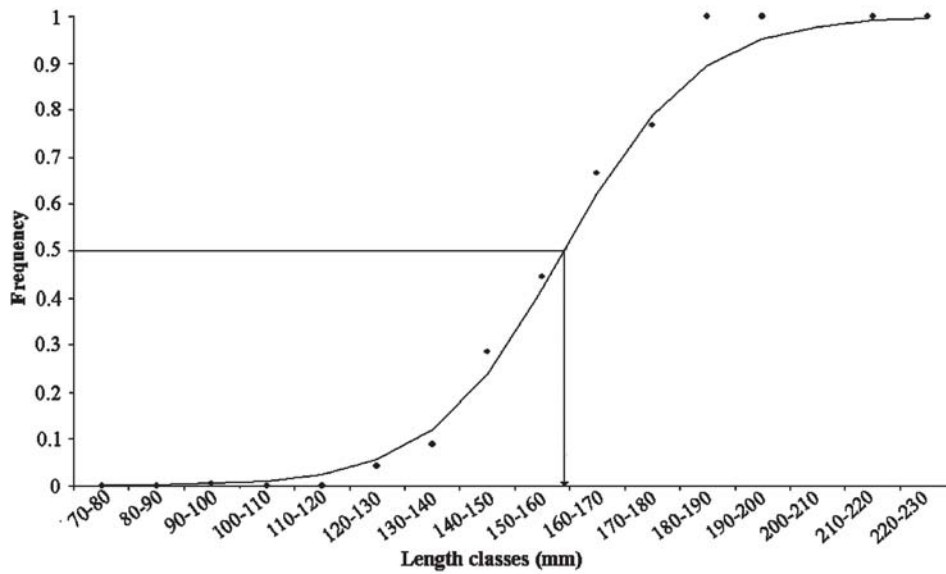


Fig. 6. Estimated length of first maturation (L_{50}) of *Isopisthus parvipinnis* (n = 990) in Ilhéus, Bahia, Brazil.

Discussion

Isopisthus parvipinnis has also been recorded as being abundant in other regions of Brazil (Sudene, 1969; Coelho *et al.*, 1986; Paiva-Filho *et al.*, 1987; Giannini & Paiva-Filho, 1994; Bail & Branco, 2003).

The aggregate pattern observed for *I. parvipinnis*, possibly reflects a patchy distribution of food resources. This distribution pattern can occur in response of the different habitat locations and seasons, due to reproductive processes and resource use optimization. The increase in competition resulting from a larger number of individuals is counterbalanced by a higher survival of the school (Gerking, 1994).

Considering temporal abundance differences, average length of individuals and frequency of adults, both autumn and winter were characterized by a higher number of individuals, mainly immature and small in size. This pattern was equally recorded by Giannini & Paiva Filho (1994) in Baía de Santos. On the other hand, in the spring and summer the abundance of *I. parvipinnis* was reduced and the few individuals captured were predominantly adults and longer in length. From these results, it can be supposed that during autumn and winter, immature *I. parvipinnis* occupy the inner shelf (16 m) of Ilhéus for growth, characterizing this period as the recruitment time of the species, whereas in the spring and summer adult individuals move to other areas for reproduction.

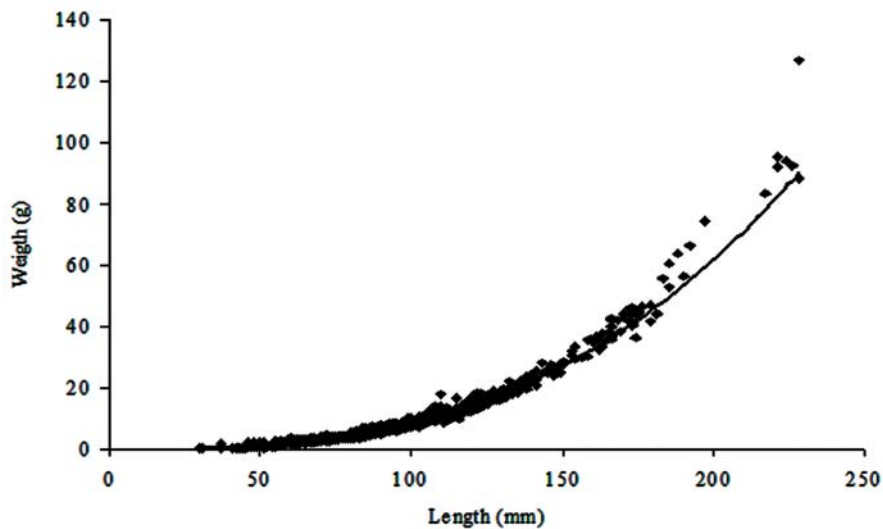


Fig. 7. Length/weight relationships of the species *Isopisthus parvipinnis* (n = 990) in Ilhéus, Bahia.

Table 2. Food categories for *I. parvipinnis* on the coast of Ilhéus – BA (% N = numeric frequency; % O = frequency of occurrence).

FOOD CATEGORIES	% N	% O
Decapoda Dendobranchiata	65	36
Dissolved organic matter (DOM)	-	30
Teleostei	27	25
Remainders of Crustacea	-	15
Teleostei scales	2	3
Decapoda	2	3
Unidentified matter	1	1
Cephalopod	1	1
Isopod Crustacea	1	1
Amphipod Crustacea	1	1
TOTAL	100	-

Similar conclusions were obtained for other regions of the Brazilian coastline. On the coast of São Paulo, Coelho *et al.* (1988) recorded the months of March and April as having the highest recruitment of *I. parvipinnis*. Recruitment during autumn and winter, and reproduction and spawning between spring and summer, were also suggested by Chaves *et al.* (1998) and Giannini & Paiva Filho (1994). However, this last work also supposes the existence of a prolonged recruitment period, from summer to winter, due to the observation of two abundance peaks of the young individuals. Soares (pers. comm.) suggests that spawning of this species, between Cabo Frio (RJ) and Torres (RS) probably occurs during the spring and that recruitment therefore occurs between summer and winter. For the coast of Ilhéus, the results seem to suggest only one recruitment period of this species between autumn and winter.

A study conducted in the Baía de Guaratuba (Paraná) by Chaves *et al.* (1998) indicates the absence of young individuals and the predominance of adults in the mangrove and estuary areas. It is suggested that the adults of this species move to the mangrove areas and bays, present on the coast of Ilhéus, during the spring and summer, and that a movement to deeper areas of the continental shelf is improbable. Although this hypothesis needs to be tested, it would explain the low abundance and absence of *I. parvipinnis* in the sampling carried out during these seasons of the year.

The estimated length of first maturation represents the size in which 50% of individuals initiate their reproductive cycle and is therefore used as a reference to determine the minimum size of resource exploitation, which, consequently, can be useful when choosing the adequate fishing methods (Vazzoler, 1996). On the coast of Ilhéus, there was a predominance of captured *I. parvipinnis* individuals with sizes under L_{50} and a low abundance of adults. As the method of capture used in this study followed the strategy adopted by shrimp trawl fisheries developed in the region, it can be concluded that this collection mainly targets the juvenile stock of *I. parvipinnis*.

The number of young individuals in the composition of bycatch is large in various regions of the country (Coelho *et al.*, 1986; Viana *et al.*, 2000; Graça-Lopes *et al.*, 2002 and Chaves

et al., 2003) and in the world (Alverson *et al.*, 1994). Removal of immature fractions of the population by means of capture as bycatch can cause a decrease in the spawning stock potential (Perra, 1992; Vazzoler, 1962). A massive capture of *I. parvipinnis* individuals on the coast of Ilhéus in the recruitment period can directly interfere with the restitution of the population of this species and with the maintenance of its ecological functions.

The dispersal of length/weight data observed and the value of “b” found ($b < 3$) are characteristics of a species with a negative allometric type of growth. According to Vazzoler (1991), low values for the allometric growth rate are expected for populations residing in open coastal areas, such as the study area. Chaves *et al.* (1998) and Giannini & Paiva Filho (1994) also noted an allometric growth for the species although the values found in these studies were higher than 3. In nature, there is a great variation in the factors mass of the gonads and stomach contents, and the different size ranges analyzed in these studies are factors that cause contrasting results for the value of “b” (Chaves *et al.* 1998).

Regarding the *I. parvipinnis* diet, a predominance of Decapoda Dendobranchiata and Teleostei, indicates that this species has a restricted food range. Studies conducted in southern and south-eastern regions of the Brazilian coastline record a broader diet for this species, although only the Teleostei and Decapoda Natantia categories have been shown to be important (Soares, 1989; Soares & Vazzoler, 2001). For the coast of Ilhéus, *I. parvipinnis* is stenophagic according to definitions presented by Zavala-Camin (1996), and carnivorous, where at least juveniles tend to consume crustaceans.

Regarding the conservation of the resources found in the bycatch, our study suggests that this sampling area could be an important growth area for *I. parvipinnis*. In order to protect this population, we suggest that a non-fishing (“defeso”) period for sea-bob shrimp (*X. kroyeri*) be established during the winter months for protection of *I. parvipinnis* recruits. Alternatives can also be adopted for the reduction of the bycatch death rate, such as the introduction of net escape devices, a decrease in trawling time and changes in the fishing period and in banned areas. Nonetheless, only the implementation of a fishery policy capable of integrating the characteristics of the target species with those of the fauna found in the same environment could minimize the magnitude of this problem.

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