

# The pink-shrimp trawling bycatch in the northern coast of São Paulo, Brazil, with emphasis on crustaceans

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## Abstract

The pink shrimp trawling fishery (*Farfantepenaeus brasiliensis* and *F. paulensis*) in the Ubatuba region acts intensely on the populations of some benthic species. The impact of fisheries on herbenthic community is unknown. Samples of herbenthic community were obtained monthly from July/1995 to August/1996. The last haul from a commercial trawler operating on the northern coast of São Paulo State and the southern coast of Rio de Janeiro State was preserved (from being discarded) and identified at the species level. 29 species of crustaceans were found, but only *Hepatus pudibundus*, *Callinectes ornatus*, *Dardanus insignis*, *Libinia spinosa*, *Sicyonia tipica*, *Portunus spinimanus*, *Portunus spinicarpus*, and *Persephona mediterranea* had high occurrence and frequency values. Such species were the main crustacean itens in the bycatch of the pink shrimp fisheries in Ubatuba for the period of study. The total bycatch was about 1502 tons, composed by 119 tons of incidental catch and 1383 tons of discarded catch. Considering the study area, these values were quite high demonstrating that some species may have been overfished.

Key words: Fisheries, pink-shrimp, bycatch, crustaceans

## Introduction

Bycatch is defined as the catch of individuals by a fishing gear which is targeting another species. The shrimp fishery is responsible for the largest bycatch among all fishing gears in the world. Whereas world shrimp landings add up to nearly around 1.8 million tons per year, the annual bycatch is circa 11.2 million tons and the discarded catch is approximately of 9.5 million tons (Alverson *et al.*, 1994). Moreover, a large amount of the catch – composed mainly by immature organisms – is rejected on board and returned to the sea since it has no commercial value, (Vazzoler, 1962). This discard has poor survival chances. Also, the rejected catch blurs stock management and assessment

programmes as the total biomass caught is clearly underestimated (Coelho *et al.*, 1986; Gasalla and Tomás, 1998), and because the predatory action of fishing on some strata of the stock (e.g., youngest individuals) is unreported (Haimovici and Mendonça, 1996).

Studies concerning rejection are scarce. Most of them refer only to finfish bycatch (Haimovici and Habiaga, 1982; Haimovici *et al.*, 1993; Haimovici and Mendonça, 1996; Kotas, 1998; Paiva-Filho and Schmigelow, 1986; Ruffino and Castello, 1992; Vianna *et al.*, 2000; Vianna and Verani, 2002; Vianna and Almeida, 2005; Vianna and D’Incao, 2006; Vieira *et al.*, 1996), because finfish are the most abundant and the most important economically (Vianna *et al.*, 2000).

This investigation reports results of the bycatch of the pink-shrimp fishery operating on the Ubatuba Coast (São Paulo State, Southeast Brazil), with emphasis on the crustacean bycatch. Composition and biomass of this bycatch is reported, and actions to decrease bycatch are suggested.

## Material and Methods

### Study Area

The area of study extends from the south of Rio de Janeiro State ('Ponta da Joatinga', 23°18'S and 44°30'W) to the north coast of the State of São Paulo (São Sebastião Island, 23°58'S and 45°13'W) (Figure 1). The submerged area was divided into two sub-areas (inner and outer domain) based on the hydrographic distributions of the water bodies. In the summer the South Atlantic Central Water (SACW) penetrates the continental shelf compressing the warmer coastal water mass. In the winter the SACW withdraws in direction of the continental shelf. The inner domain comprises depths ranging from 40 to 50 m, and it is approximately 50km wide. The outer domain extends up to the shelf break with depths ranging from 50 to 120 m. The widest continental shelf in the submerged area allows bottom trawling for shrimps, making the Ubatuba region one of the most important fishing grounds of the State of São Paulo. The limit of the inner domain comprise the studied area of this investigation. This studied area is characterized by a mixing zone of water masses and it is a dynamic subsystem which changes seasonally.

### Biological Sampling

Samples were obtained monthly from July/1995 to August/1996 using a typical boat of the commercial fleet of the pink-shrimp fishery. Between March and April/1996, there was no sampling because of the enforced closed season of the pink-shrimp fishery. The collected material was composed of the total catch, free from selection or discard, provided by a haul carried out by a 17 m (55 ft) boat equipped with a double-outrig-

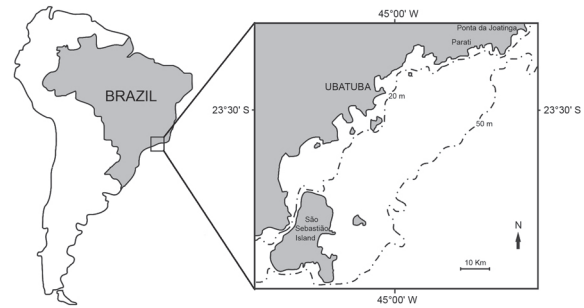


Figure 1. Map of the studied area. Depth contours are in meters.

ger otter trawl. The dimensions of the net used were 25 mm mesh size from opposite knots on condend; length of 18 m on the top side of the net, and 20 m on the down side. Boat speed was maintained around 2.5 knots, and each haul lasted between three and six hours. Trawling was carried out always at night with depths ranging from 31 to 51 m. Samples collected were frozen and taken to the laboratory where individuals were sorted by species, fixed (10% formaldehyde), preserved (70% ethanol), sexed, and weighted (wet weight, after blotting in a paper, 1 g accuracy).

### Crustacean Catch Composition

For each crustacean species, it was computed total number of individuals and total weight.

Relative abundance, catch-per-unit-of-effort (CPUE), was calculated for each species and total catch. CPUE was expressed in numbers of individuals per hour of trawling ( $\text{ind. h}^{-1}$ ), and in total weight per hour of trawling ( $\text{g. h}^{-1}$ ).

### Estimate of the bycatch in the Ubatuba region for the period from July/1995 to August/1996

Production data of the studied area, in kg, regarding pink-shrimp landings and the incidental catch of finfish was obtained on a fishery database of the State of São Paulo (Propesq). Other data regarding incidental and discarded catch, in kg, was obtained exclusively from the monthly trawlings of a typical boat of the commercial pink-shrimp fleet. Effort (f), in hours of trawling, was obtained on the Propesq database (Table 1).

Apart from the targeted-species (pink-shrimp), the commercial fleet lands only finfish with commercial value. This catch is defined incidental catch. This incidental catch was divided into two groups: the first, named partially used, was composed by individuals with commercial size; the second, named partially discarded, was composed by individuals with no commercial size.

The incidental catch was categorized as follows: “fish partially used” (FPU), “cephalopod 100% used” (CU) (squids and octopi – *Loligo plei*, *L. sanpaulensis* and *Octopus vulgaris*), and “swimming crab 100% used” (SCU) (*Portunus spinimanus*). The discarded catch was divided in the following categories: “fish 100% discarded” (FD), “fish partially discarded” (FPD), “crustaceans 100% discarded” (CD), and “other 100% discarded” OD (Porifera, Cnidaria, Polychaeta, Mollusca, Echinodermata, Urochordata, etc.).

For data analysis it was calculated monthly values of CPUE for categories CU, SCU, FD, FPD, CD, and OD. Later, each category CPUE was multiplied by the monthly effort (h) of the fleet operating in the region (total fleet effort). Monthly CPUE of each category were summed over the sampling period, and after adding to this subtotal the total capture of the fish partially used (FPU), it was obtained the estimate of the total bycatch. The proportion bycatch/pink-shrimp was obtained by the quotient between total bycatch and the pink-shrimp total capture for the period.

## Results

### Crustaceans Catches Compositions

Twenty nine species of crustaceans, which represented a total number of 4.739 individuals (100.8 ind. h<sup>-1</sup>), and a total production of 64 kg (1364.1 g h<sup>-1</sup>) were collected (Table 2). *Hepatus pudibundus* was the most abundant species (950 ind.) representing 20% of the whole crustacean catch (17.9 ind. h<sup>-1</sup>). This species also appeared more frequently during the sampling period. The second most abundant species was *Callinectes ornatus*, which summed to 803 individuals (15.2 ind. h<sup>-1</sup>). However, in relation to biomass, *Libinia spinosa* was the most important species, with a total catch weighting 18 kg (29% of total), representing a CPUE of 351 g h<sup>-1</sup>. *Hepatus pudibundus* and *C. ornatus* had the second and the third highest biomass totalizing 16 and 10 kg (308 g h<sup>-1</sup> and 192.4 g h<sup>-1</sup>), respectively.

### Estimate of the bycatch for the period from July of 1995 to August of 1996 to Ubatuba

The estimate of the total bycatch (Table 3) was 1502 tons, which means a proportion bycatch/pink-shrimp 34.1:1. Fish contribute with the largest portion in the incidental and discarded catch. In the incidental catch, the second largest contribution was composed by cephalopods, followed by swimming crabs (*Portunus spinimanus*). In

**Table 1.** Effort data, catches (kg) and catch-per-unit-of-effort (CPUE kg/h) from Propesq and from the Fishing Boat. (FPU) Fish partially used, (CU) cephalopod used, (SCU) swimming crab used, (FD) fish discarded, (FPD) fish partially discarded, (CD) crustaceans discarded and (OD) other discarded. TS – target species.

	Propesq data					Fishing Boat Data											
	Categories					Categories											
	f (h)	TS (kg)	TS (kg/h)	FPU (kg)	FPU (kg/h)	CU (kg)	CU (kg/h)	SCU (kg)	SCU (kg/h)	FD (kg)	FD (kg/h)	FPD (kg)	FPD (kg/h)	CD (kg)	CD (kg/h)	OD (kg)	OD (kg/h)
July	2261	3812	1.69	11426	5.05			1.13	0.23	191.30	38.26	57471.29	25.42	12.61	2.52	26.48	5.30
August	2910	4842	1.66	9513	3.27											15.8	3.95
September	2759	4923	1.78	7069	2.56	6.94	1.39	0.16	0.03	60.37	12.07	8736.65	3.17	15.30	3.06	19.16	3.83
October	1824	3340	1.83	4839	2.65	1.50	0.38	6.62	1.66	207.62	51.91	57500.83	31.52	14.89	3.72	15.24	3.81
November	1680	2831	1.69	4402	2.62	1.82	0.46	0.45	0.11	163.54	40.89	28334.33	16.87	12.60	3.15	17.86	4.47
December	2264	2841	1.25	6542	2.89	1.08	0.27	1.50	0.38	125.74	31.44	30367.25	13.41	6.64	1.66	13.12	3.28
January	1884	2924	1.55	6605	3.51	12.50	3.57			22.18	6.34					26.06	7.45
February	1404	1131	0.81	2328	1.66	19.30	4.83	1.27	0.32	67.34	16.84	7923.42	5.64	2.53	0.63	4.9	1.23
May	1615	4146	2.57	5947	3.68	5.30	1.33	0.70	0.17	159.10	39.78	38742.71	23.99	7.58	1.89	24.82	6.21
June	2268	5451	2.40	9190	4.05	0.54	0.14	0.99	0.25	326.44	81.61	146885.87	64.76	17.98	4.50	6.88	1.72
July	2704	4755	1.76	10448	3.86	0.14	0.02	2.41	0.40	207.56	34.59	61751.85	22.84	24.26	4.04	33.64	5.61
August	2339.5	3018	1.29	10996	4.70	0.18	0.05	1.89	0.47	60.62	15.16	6486.62	2.77	0.80	0.20	24.00	6.00
<b>Total</b>	<b>25912.5</b>	<b>44014</b>	<b>20.28</b>	<b>89305</b>	<b>40.51</b>	<b>49.30</b>	<b>12.41</b>	<b>17.12</b>	<b>4.02</b>	<b>1591.82</b>	<b>368.87</b>	<b>444200.82</b>	<b>210.40</b>	<b>115.19</b>	<b>25.38</b>	<b>227.96</b>	<b>52.84</b>
<b>Mean</b>			<b>1.69</b>		<b>3.38</b>		<b>1.24</b>		<b>0.40</b>		<b>33.53</b>		<b>21.04</b>		<b>2.54</b>		<b>4.40</b>

the discarded catch, the largest contribution, after the category fish, was formed by the category other (8.3%). It is important to note that this category is composed by several zoological groups. The category crustaceans was analyzed separately and contributed with around 4% of the whole discards.

In relation to the discarded crustaceans, it was observed that the crab *H. pudibundus* summed circa 29.5% of the catch, which represented an estimate of 16 tons for the study period (Table 4).

## Discussion

### Crustaceans Catches Compositions

Bycatch is characterized by a high diversity and a great amount of biomass compared with the target-species, varying seasonally and regionally (Branstetter, 1997). Moreover, while each fish-

ery, with its respective fishing gear, has its typical bycatch, the shrimp trawling is undoubtedly the most damaging fishery activity in terms of biomass bycatch (Vianna and Almeida, 2005).

A characteristic of the shrimp fishery bycatch in tropical waters is the great number of species caught with only a few dominant ones (Clucas, 1998). Data in the present investigation supports this statement, as 29 species of crustaceans were found in the bycatch of the pink-shrimp fishery.

*Hepatus pudibundus* was a recurrent species with high values of relative abundance in all trawlings. While *L. spinosa* contributed with the second largest weight CPUE, its relative abundance was the fifth largest. This is explained by the large size of *L. spinosa* individuals, which were usually larger than most of the species captured, including *H. pudibundus*. Although Melo (1996) has mentioned *L. spinosa* as a frequent species in some kinds of fishing trawlings, *H. pudibundus* and *C. ornatus* were the most important bycatch in the pink-shrimp

**Table 2.** Species found in the bycatch crustaceans of the pink-shrimp fishing in Ubatuba – SP. CPUE, total weight in grams and individuals total number for species.

Species	Total weight (g)	CPUE (gr/h)	total n°	CPUE (ind/h)
<i>Squilla brasiliensis</i>	139.44	2.63	42	0.79
<i>Hemisquilla brasiliensis</i>	96.97	1.83	5	0.09
<i>Artemesia longinaris</i>	147.71	2.79	65	1.23
<i>Farfantepenaeus brasiliensis</i>	166.36	3.14	14	0.26
<i>Farfantepenaeus paulensis</i>	362.69	6.84	28	0.53
<i>Rimapenaeus constrictus</i>	1032.30	19.48	508	9.58
<i>Xiphopenaeus kroyeri</i>	547.21	10.32	152	2.87
<i>Sicyonia tipica</i>	1271.85	24.00	373	7.04
<i>Pleoticus muelleri</i>	155.02	2.92	43	0.81
<i>Scyllarides deceptor</i>	144.35	2.72	7	0.13
<i>Scyllarus depressus</i>	7.21	0.14	1	0.02
<i>Pagurus excilis</i>	16.81	0.32	13	0.25
<i>Dardanus insignis</i>	3019.76	56.98	584	11.02
<i>Loxopagurus loxochelis</i>	0.82	0.02	1	0.02
<i>Petrochirus diogenes</i>	541.89	10.22	10	0.19
<i>Porcellana sayana</i>	0.48	0.01	5	0.09
<i>Hypoconcha arcuata</i>	2.20	0.04	1	0.02
<i>Hepatus pudibundus</i>	16324.14	308.00	950	17.92
<i>Persephona mediterranea</i>	1720.35	32.46	207	3.91
<i>Persephona punctata</i>	21.87	0.41	9	0.17
<i>Leurocyclus tuberculatus</i>	50.24	0.95	20	0.38
<i>Stenocionops spinosissima</i>	1.09	0.02	1	0.02
<i>Libinia spinosa</i>	18646.98	351.83	380	7.17
<i>Parthenope (Platylambrus) pourtalesii</i>	67.58	1.28	7	0.13
<i>Arenaeus cribrarius</i>	133.58	2.52	2	0.04
<i>Callinectes ornatus</i>	10197.06	192.40	803	15.15
<i>Portunus spinimanus</i>	8632.43	162.88	231	4.36
<i>Portunus spinicarpus</i>	660.79	12.47	274	5.17
<i>Pilumnus caribaens</i>	2.77	0.05	3	0.06
<b>Total</b>	<b>64111.95</b>	<b>1364.08</b>	<b>4739</b>	<b>100.83</b>

**Table 3.** Monthly and total catch values (kg) from target species (TS) and fish partially used (FPU), catch-per-unit-of-effort (CPUE kg/h) and catches estimates (CPUE kg/h x f) from the categories (CU) cephalopod used, (SCU) swimming crab used, (FD) fish discarded, (FPD) fish partially discarded, (CD) crustaceans discarded and (OD) other discarded; total bycatch (kg) and proportion bycatch/pink-shrimp (total bycatch/TS (kg)).

	Propesq data Categories			Fishing Boat Data Categories												
	f (h)	TS (kg)	FPU (kg)	CU (kg/h)	CU est (kg)	SCU (kg/h)	SCU est (kg)	FD (kg/h)	FD est (kg)	FPD (kg/h)	FPD est (kg)	CD (kg/h)	CD est (kg)	OD (kg/h)	OD est (kg)	
July	2261	3812	11426			0,23	512.79	38.26	86505.86	25.42	57471.29	2.52	5702.69	5.30	11974.26	
August	2910	4842	9513											3.95	11494.50	
September	2759	4923	7069	1.39	3829.49	0.03	87.46	12.07	33312.17	3.17	8736.65	3.06	8439.86	3.83	10572.49	
October	1824	3340	4839	0.38	684.00	1.66	3018.72	51.91	94676.54	31.52	57500.83	3.72	6791.57	3.81	6949.44	
November	1680	2831	4402	0.46	764.40	0.11	190.68	40.89	68686.80	16.87	28334.33	3.15	5291.92	4.47	7501.20	
December	2264	2841	6542	0.27	611.28	0.38	850.13	31.44	71168.84	13.41	30367.25	1.66	3758.01	3.28	7425.92	
January	1884	2924	6605	3.57	6728.57			6.34	11940.25					7.45	14027.73	
February	1404	1131	2328	4.83	6774.30	0.32	445.77	16.84	23636.34	5.64	7923.42	0.63	887.82	1.23	1719.90	
May	1615	4146	5947	1.33	2139.88	0.17	281.82	39.78	64236.63	23.99	38742.71	1.89	3059.70	6.21	10021.08	
June	2268	5451	9190	0.14	306.18	0.25	559.06	81.61	185091.48	64.76	146885.87	4.50	10196.93	1.72	3900.96	
July	2704	4755	10448	0.02	63.09	0.40	1085.21	34.59	93540.37	22.84	61751.85	4.04	10932.81	5.61	15160.43	
August	2339.5	3018	10996	0.05	105.28	0.47	2815	1106.15	15.16	35455.12	2.77	6486.62	0.20	468.45	6.00	14037.00
<b>Total</b>		<b>44014</b>	<b>89305</b>		<b>22006.47</b>		<b>8137.79</b>		<b>768250.40</b>		<b>444200.82</b>		<b>55529.77</b>		<b>114784.89</b>	
<b>Bycatch</b>	<b>1502.215</b>															
<b>Proportion</b>	<b>34.1: 1</b>															

**Table 4.** Bycatch estimates in tons for the period 1995/1996.

	Tons	%
Target-species	44	2,8%
Bycatch	1502	97,2%
Incidental catch	119	8%
Discarded catch	1383	92%
Incidental catch	119	
Fish	89	74,8%
Cephalopod	22	18,4%
<i>Portunus spinimanus</i>	8	6,8%
Discarded catch	1383	
Fish	1212	87,7%
Crustaceans	55	4%
Others	115	8,3%
Crustaceans	55	
<i>Hepatus pudibundus</i>	16	29,5%

trawling fishery. *Sicyonia tipica*, *Dardanus insignis*, *Persephona Mediterranea*, *Portunus spinimanus* and *Portunus spinicarpus* were also common, because they had 100% of frequency in the samplings. Therefore, the latter species plus *H. pudibundus*, *C. ornatus* and *L. spinosa*, characterize the crustacean bycatch of the pink-shrimp trawling fishery in Ubatuba for the period 1995/1996. Although *Rimapenaeus constrictus* and *Xiphopenaues kroyeri* have shown high values of relative abundance, they were not constant during sampling period. Their catches can be considered occasional because *X. kroyeri* rarely crosses the 30 meters isobath and *R. constrictus* is considered a coastal species, in spite of being men-

tioned up to the 100 meters isobath. Other species of crustaceans found in the samples did not present a clear pattern of frequency of occurrence.

Estimate of the bycatch for the period from July/1995 to August/1996 in the Ubatuba region.

Although *H. pudibundus* has been the most representative species in the catch it is probable that other species such as *Callinectes ornatus*, *Dardanus insignis*, *Libinia spinosa*, *Sicyonia tipica*, *Persephona mediterranea*, *Portunus spinimanus*, and *Portunus spinicarpus* can have high fishing mortality levels due the high number of individuals collected in the samplings. In the same way similarly, many other species of fish, crustaceans, mollusks and other sea organisms found in the bycatch can be threatened. This is corroborated by the estimate of the discarded catch that was around 1383 tons or 92% of the whole catch, considering only the pink-shrimp trawling fishery in the area. According to Kotas (1998) at least ten species of crustaceans (crabs, swimming crabs, mantis shrimps and flat lobsters) were found as bycatch of shrimp fisheries in Santa Catarina State, which circa 80% were rejected; only *Portunus spinimanus* and *Scyllarides deceptor* were valuable economically.

A total of 119 tons of incidental catch represented 8% of the total catch. Recent figures suggest that the use of the incidental catch in Brazil has an increasing trend over years and it probably

represents 10% of the bycatch (Clucas, 1997). Increase in landings of the incidental catch is a reflex of overfishing on the target-species, as pink-shrimp stocks in the south-southeast Brazil have been drastically reduced; it results in a shift in the past exploitation pattern as many fishermen use now incidental catch in an attempt to increase the diminished profit from the pink-shrimp fishery (D’Incao et al., 2002). Overfishing also influences the proportion bycatch/pink-shrimp; the smaller the pink-shrimp catch the larger is the bycatch.

The proportion bycatch/pink-shrimp found in Ubatuba region was 34.1:1. This figure is much higher than the proportion 9.3:1 reported for the Brazilian coast (Alverson et al., 1994). Studying the shrimp fishery in Kuwait, Ye (2000) observed in Summer a proportion bycatch/shrimp of 35.9:1, which is similar to the estimate for Ubatuba; however, in Autumn this proportion was 5.5:1. Vianna and Almeida (2005) studying the fish bycatch of the same region, and at the same period of the present work, observed that due the inflowing and outflowing of the water masses the composition and the abundance of species show oscillations, leading to shifts of distribution which are related with temperature and depth. This seasonal pattern in the distribution and abundance of the fish confirmed that the region contained tropical and sub-tropical species with preference for particular water masses.

Besides the reported values above, all known proportions of bycatch/shrimp refers to the fish bycatch. Other zoological groups that integrate bycatch are not included in the official statistics. Therefore, these proportions would not represent the total values of the bycatch, which probably results in underestimated proportions. Therefore, the multi-species character of the shrimp trawling fishery is not considered. Their estimates are incomplete due the lack of data of other zoological groups. Even if sometimes the biomass is small, it means an important portion of the bycatch. A small catch in weight may represent a massive catch if it is consider the number (N) of individuals. Therefore, all sort of data should be included in the official statistics in an attempt to make catch estimates more realistic.

Another important point to consider is that some species of crustaceans, either with commer-

cial value or not, such as *Hepatus pudibundus*, *Callinectes ornatus*, *Libinia spinosa*, *Sicyonia tipica*, *Dardanus insignis*, *Persephona Mediterranea*, *Portunus spinimanus*, and *Portunus spinicarpus*, have been intensely captured by shrimp trawlings. The evaluation of the stock of this non-target species is needed. For instance, a study regarding growth and mortality of *H. pudibundus* (Keunecke et al., 2007) suggests the possibility of recruitment overfishing for this species.

The present work suggests further studies about the implementation of bycatch reduction devices (BRDs) in trawl nets. The use of BRDs has been studied in trawling fisheries in Australia and USA. In Brazil, only Vianna and D’Incao (2006) assessed the use of BRDs in an artisanal fishery in Patos Lagoon. They concluded that simple changes in the configuration of conventional nets lead to a reduction of unwanted bycatch of fish and crabs, and that the use of BRDs should be extended to the productive sector. Only joint actions including co-management among the government, the production sector and research institutes will be capable to find solutions for the bycatch problem (Vianna and Almeida, 2005).

## Acknowledgements

The authors thank the researchers Hélio Valentini and Marcus Henrique Carneiro from São Paulo Fishing Institute for the supply of fishing production data and CAPES and CNPq for the scholarships to the first author.

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Received: January 2007

Accepted: August 2007