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Demersal ichthyofauna in a continental shelf region on the south coast of Brazil exposed to shrimp trawl fisheries

Ictiofauna demersal numa região de plataforma continental do sul do Brasil submetida à pesca camaroeira

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Bycatch is a common event in fishing activities, affecting not only fish and invertebrates, but also birds, mammals and turtles, for example (Perez & Pezzuto, 1998; Hall, Alverson & Metuzals, 2000; Fonteyne & Polet, 2002). In shrimp trawl fisheries, the bycatch can surpass 60% of the capture in mass (Walter & Becker 1994; Diamond, Crowder & Cowell, 1999), involving, above all, fish that are discarded for not having adequate economic value (Vieira, 1996; Hill & Wassenberg, 2000). There is evidence that the consequences of this practice are not just environmental, but also of a direct economic order. Berghahn, Waltemath & Rundsorp (1992) and Diamond, Cowell & Crowder (2000) demonstrate that, in species of gadiforms and in the Atlantic croaker, respectively, the

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discard of juvenile fish affects the stock of species that have a commercial value.

The implications of the bycatch vary from place to place and throughout time (ANDREW & PEPPERELL, 1992). In the Parana coast, Southern Brazil, this practice embodies a particularly serious subject, given the dimension at which it occurs. As this is the segment of the Brazilian coast in which the volume of artisanal fishing surpasses that of the industrial fishing (PAIVA, 1997), most of the boats that operate here are small, with a gross load capacity usually inferior to 20 t. Most of them fish at depths of up to 10m, during nine months of the year, in the modality of shrimp trawl fisheries. In fact, shrimps correspond to 60-70% of the catch landed in the coast of the State (IBAMA/Paranagua, General Fishing Record 2000, unpublished data). The boats do not trawl at greater depths because they would not have enough power to haul heavier gear, besides the fact that their target shrimp becomes more rare as from 10m. Because the nets do not use bycatch reduction devices, and because of the technical and biological elements mentioned above, the ichthyofauna of the Parana coast is pressured in different ways at depths inferior to 10m and superior to 10m. This study investigated whether the attributes of the fish assemblage that occupies this region differ between the area submitted to this type of fishing and the area where this type of impact does not occur.

MATERIAL AND METHODS

Sampling was performed monthly between March 1999 and January 2000 (except in September) at daytime, using bottom trawl nets, similar to shrimp nets (bag with mesh of 2.5cm between opposite knots). Every month, trawling was accomplished for 10 minutes in two parallel transects to the beach of the district of Matinhos (25°45'S; 48°20'W): three trawl operations between the islands Itacolomis and Currais, isobath 15m, an area where shrimp trawl fisheries does not occur; and three (two in March) at isobath 10m, an area traditionally used by shrimp trawl fisheries.

After identifying the species, the specimens were measured (total length) and weighed. The sex was established, and the degree of

gonad maturation estimated according to the literature about these species, or others from the same taxonomic group. To standardize the treatment of the data, a simple scale of maturation was used based on VAZZOLER (1996), composed of four stages: A, immature or resting gonad; B: gonad in maturation; C, mature gonad; and D, total or partially emptied gonad. Individuals in the latter two stages were classified as being in reproductive activity.

The opening of the net and the speed of the craft boat were considered to be similar between operations. Thus, the variations in specific richness and abundance (number, biomass) between the months and between the areas were calculated in terms of capture per time of trawling ($CPUE_{n,b}$). For the analysis of differences between the mean abundance and individual length values, Analysis of Variance (ANOVA) statistical tests were accomplished after performing the normality tests.

RESULTS

Sixty-two species were recognized in the area, of which 30 were common to both areas, 24 occurred exclusively at 10m and eight occurred exclusively at 15m. Eleven of the species were present every month, five of which occurred only at 10m; none of these species occurred only at 15m. Most of the species was recorded for a maximum of 30% of the months at 10m, and 20% at 15m (Table I).

The monthly mean specific richness varied between the months. At 10m, it varied between 6.3 and 20.7 species.$10mn^{-1}$ of trawling and at 15m between 3.7 and 14.7 species.$10mn.^{-1}$ of trawling (Fig. 1). It was significantly higher at 10m in December and in January. Differences between months were only recorded at 10m where, in June and December the number of species was higher than in the other months.

The mean CPUE in number of individuals was different between the areas during part of autumn, spring and summer, being larger at 10m than at 15m (Fig. 2). Differences between the months were recorded in both areas, but in another way: while at 15m the maximum abundance of individuals occurred in June and July, at 10m it

Table 1 – Species caught in the studied region and their frequency of occurrence (F.O.) in 10 months between March 1999 and January 2000, according to the area. [: 10m (shrimp fisheries area); ♦: 15m.]

Species	F.O.(%)	♦	Species	F.O.(%)	♦
Paralonchurus brasiliensis	100	50	*Stellifer stellifer*	30	0
Micropogonias furnieri	100	40	*Trinectes microphthalmus*	30	0
Pellona harroweri	100	40	*Chaetodipterus faber*	20	0
Isopisthus parvipinnis	100	40	*Harengula clupeola*	20	0
Trichiurus lepturus	100	20	*Orthopristis ruber*	20	0
Menticirrhus americanus	90	70	*Diplectrum radiale*	10	60
Larimus breviceps	90	50	*Synodus foetens*	10	60
Stellifer brasiliensis	90	20	*Citharichthys arenaceus*	10	50
Chirocentrodon bleekerianus	80	50	*Zapteryx brevirostris*	10	20
Conodon nobilis	80	0	*Sphyraena guachancho*	10	10
Anisotremus surinamensis	70	90	*Cathorops spixii*	10	0
Ophioscion punctatissimus	70	50	*Bairdiella ronchus*	10	0
Peprilus paru	70	20	*Hemicaranx amblyrhynchus*	10	0
Chloroscombrus chrysurus	60	70	*Macrodon ancylodon*	10	0
Cynoscion leiarchus	60	60	*Nebris microps*	10	0
Sphoeroides greeley	60	40	*Netuma barba*	10	0
Lycengraulis grossidens	60	20	*Polydactylus virginicus*	10	0
Selene setapinnis	60	10	*Porichthys porosissimus*	10	0
Trachinotus paulistanus	60	0	*Rypticus randalli*	10	0
Prionotus punctatus	50	80	*Sphyraena picudilla*	10	0
Etropus crossotus	40	80	*Stephanolepis hispidus*	10	0
Citarichthys spilopterus	40	30	*Trachinotus carolinus*	10	0
Selene vomer	40	20	*Achirus lineatus*	10	0
Narcine brasiliensis	40	10	*Syacium papillosum*	0	60
Urophycis brasiliensis	40	10	*Eucinostomus argenteus*	0	30
Stellifer rastrifer	40	0	*Eucinostomus gula*	0	30
Lagocephalus laevigatus	40	0	*Rhinobatos horkelli*	0	20
Symphurus tessellatus	40	0	*Rhinobatos percellens*	0	10
Diapterus rhombeus	30	90	*Balistes capriscus*	0	10
Chylomicterus spinosus	30	50	*Bothus robinsi*	0	10
Centropomus parallelus	30	0	*Diplectrum formosum*	0	10

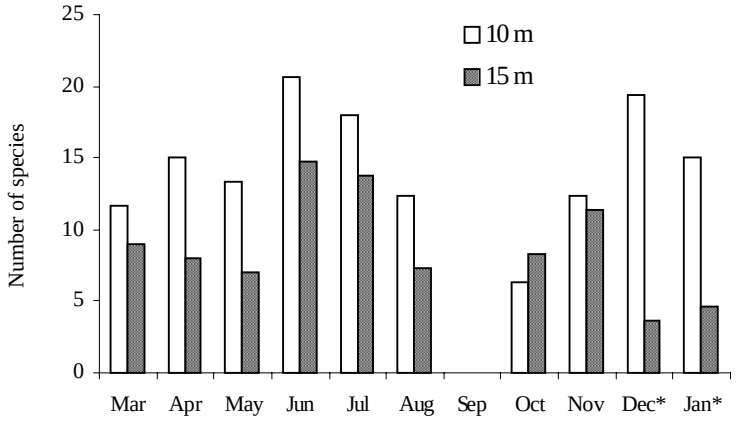


Fig. 1. Mean monthly specific richness (in number of species per 10 minutes of trawling) according to the area, 10 or 15m. *: significant difference between areas (<0.05).

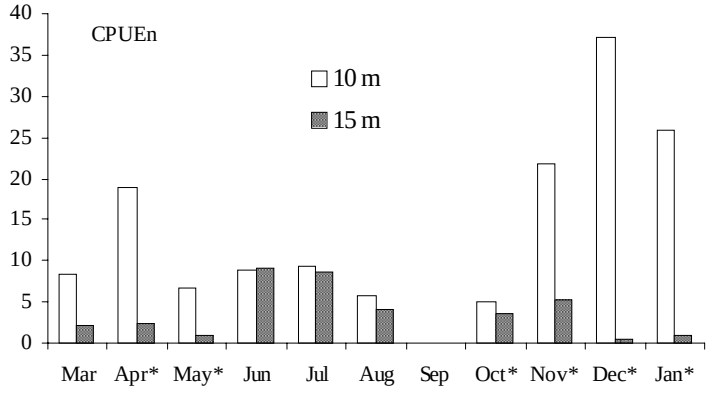


Fig. 2. Mean monthly numeric abundance ($CPUE_n$, number of individuals per minute of trawling) according to the area, 10 or 15m. *: significant difference between areas (<0.05).

was higher at the end of spring and during part of the summer and autumn. The mean CPUE in mass was larger at 10m than at 15m in April, August and January, and larger at 15m than at 10m in October (Fig. 3). On a temporal scale, it was larger at the end of spring and beginning of summer than in the other periods, however this was only true for the 10m area.

The relationship between specific richness and numeric capture gives a curve with two different segments (Fig. 4). The first, steeper segment, corresponds to the 15m area; here the $CPUE_n$ values are low, but the increment rate in the number of species is high. The second segment, with a gentle slope, corresponds to the 10m area; here the $CPUE_n$ values are high, but the increment rate in the number of species is smaller.

The most represented groups in the captures were, in number of species, Clupeiformes and Sciaenidae; in number of individuals, Sciaenidae and Pleuronectiformes; and in biomass, Sciaenidae (Fig. 5). On a species level, *Cheirocentrodon bleekerianus*, *Pellona harroweri* and *Anisotremus surinamensis* were more abundant numerically in three or more months; the former in both areas; the second, only at 10m; and the latter, only at 15m. Other species that stood out in abundance, according to the month, were *Stellifer stellifer*, *Isopisthus parvipinnis, Paralonchurus brasiliensis* and *Trichiurus lepturus* at 10m, and *Ophioscion punctatissimus*, *Prionotus punctatus*, *Chloroscombrus chrysurus*, *Eucinostomus argenteus* and *Lycengraulis grossidens* at 15m.

The size of the individuals for all the species together was different between the two areas (except in March and June): in August, individuals at 10m were larger than the one at 15m; in all other months, they were smaller (Fig. 6).

Individuals in the four maturation stages were found in the two areas. The 10m are had individuals in reproductive activity every month; this occurred in 80% of the months at 15m. In both areas, the frequency of individuals in reproductive activity (mature or post-spawning) was superior to 30% during the spring and in the beginning of summer (Figs 7 and 8).

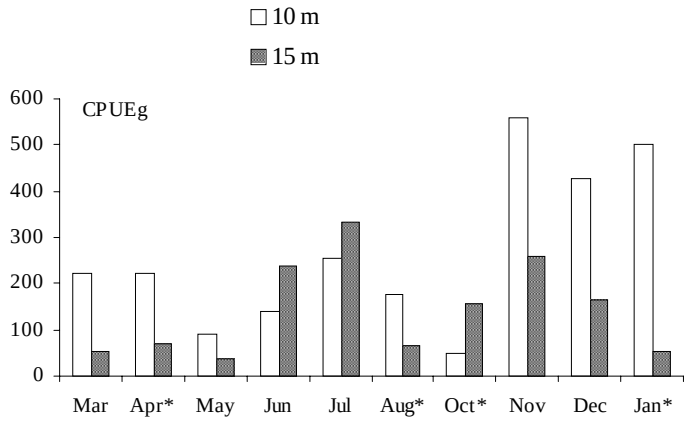


Fig. 3. Mean monthly abundance in biomass ($CPUE_b$, g of individuals per minute of trawling) according to the area, 10 or 15m; *: significant difference between areas (<0.05).

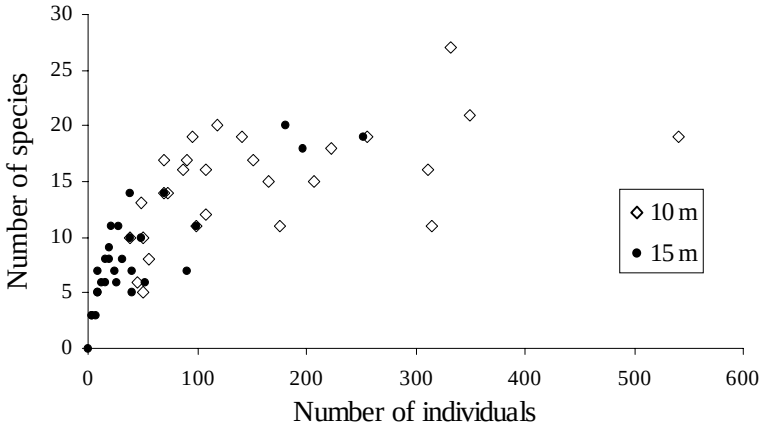


Fig. 4. Distribution of the number of species present in the samples according to the number of individuals caught by area, 10 or 15m.

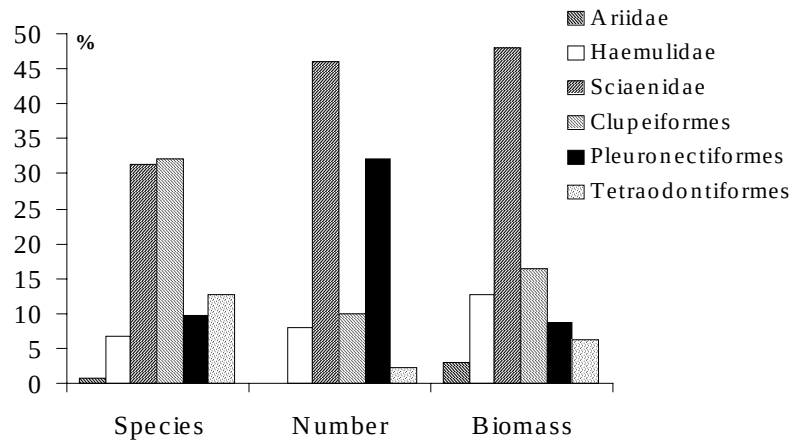


Fig. 5. Relative distribution of the main taxonomic groups recorded in the study region, in number of species, number of individuals and total biomass.

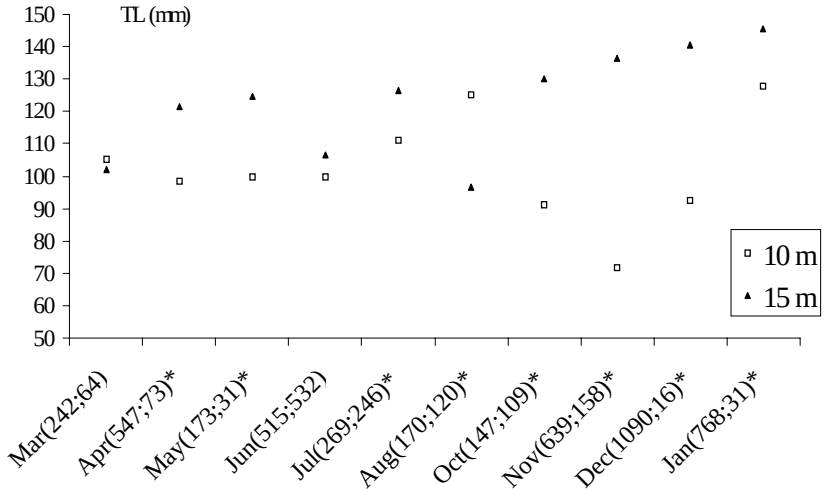
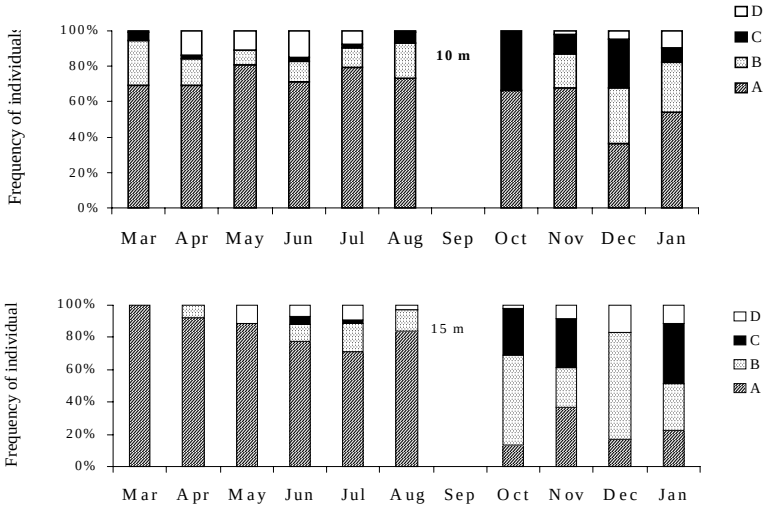


Fig. 6. Mean values in the total length (TL) of the individuals in the 10 and 15m areas, according to the month (March 1999 to January 2000). Brackets: sample size at 10 and 15m, respectively; *: significant difference between areas (<0.05).



Figs 7 and 8. Monthly distribution of the percentage of individuals in each maturation stage (A to D): 7 (above), in the shallow area (10m), 8 (bellow), in the deep area (15m), from both sexes and all the species together.

The ichthyofaunistic composition of the studied region is similar to that of other sections of the internal shelf of Southern-Southeastern Brazil (32-33ºS — HAIMOVICI, 1998; 23-24ºS — ROCHA & ROSSI-WONGTSCHOWSKI, 1998). In all of them, the largest abundance of Sciaenidae is noticeable, although there are differences at the species level. Clupeiformes, Gerreidae, Haemulidae, Pleuronectiformes and Tetraodontiformes are among the dominant groups in at least two of these regions, and they also show particularities at the species level.

On the coast of Parana, the shrimp trawl fisheries are not usually accomplished depth 15m. However, the employment of this technique has standardized the sampling instrument, permitting the comparison of the ichthyofaunistic attributes between the two areas. The increment in the number of species being related to an increase in the capture is larger at 15m than at 10m, indicating that in the latter the species form larger assemblages, which also result in larger

total captures. Clupeiformes and Sciaenidae, the abundance of which is more uniform throughout time at 10m than at 15m, are valued commercially when their individuals are adult. Therefore, the discarding of juveniles by the shrimp trawl fisheries is supposed to compromise the economic use of part of the fishing resources of the region. In spite of the individuals being, in general, larger at 15m, this area has a smaller direct economic value, given the nature of the groups that are more regularly present here (Haemulidae, Tetraodontiformes).

Few species are present every month in both areas, therefore most of the fish populations that use this region are probably not resident and their presence is associated to migratory behaviors, some of which have a reproductive nature. The life cycle of some of these species involves nearby estuarine environments, like Guaratuba Bay (Gerreidae — CHAVES & OTTO, 1998, 1999), or deeper zones of the shelf (croaker — ROBERT & CHAVES, 2001). Both areas (10 and 15m) seem to be used for spawning, although not by the same species, because most of them are exclusive to one area or another.

It can be concluded that the ichthyofauna of the area where shrimp trawl fisheries occur possesses singular characteristics, different from those of the area free from this practice. The process of bycatch affects not a simple extension of a fish assemblage, but a particular unit, with exclusive attributes. The impacts provoked by the discarding of fish at 10m cannot be compensated by the simple absence of fishing at 15m. Although the areas are linked physically, each one has its own ichthyofaunistic identity. The introduction of equipments such as bycatch reduction devices (BROADHURST, KENNELLY & O'DOHERTY, 1997; ROGERS *et al*., 1997) or the adaptation of the current fishing gears (HANNAH & JONES, 2000) should therefore be enforced in the region.

SUMMARY

A region of the Continental Shelf of Southern Brazil, isobaths 10 and 15 meters, was studied aiming to compare the attributes of the fish assemblage exposed to the shrimp trawl fisheries, to those

of a fish assemblage from a contiguous deeper area that is not exposed to this fishing modality. Individuals were collected with bottom trawl net along 1999 and 2000, and its composition, abundance, size and reproductive activity were analyzed. Of the sixty-two fish species, 30 were common to both areas, while 24 were exclusive to the fishing area and eight were exclusive to the non-fishing area. The shrimp trawl fisheries and the bycatch associated to it occur in a shelf area having very distinctive ichthyofaunistic attributes when compared to those found in the area where this type of fishing does not occur. These attributes include a high number of species exclusive to the fishing area, the formation of larger populational aggregates, a higher intensity of reproductive activity, a larger permanence of species with potential economic value, and a smaller mean individual size. There is evidence that many species do not reside in the study region, but are present because of their migratory behavior. Species whose individuals are valued commercially when adults (mainly Clupeiformes and Sciaenidae) present more uniform abundance values through time in the fishing area than in the contiguous area, where many important groups with no commercial interest (Haemulidae, Tetraodontiformes) were recorded. It is estimated that the ichthyofauna of the area presenting shrimp trawl fisheries is exposed to a disturbance that cannot be counterbalanced by the absence of this fishery activity in its contiguous area.

KEY WORDS; fisheries, fish, shrimp, bycatch, Brazil.

RÉSUMÉ

Ichtyofaune démersale dans une région du plateau continental sud-brésilien soumise à la pêche aux crévettes. L'ichtyofaune d'une région du plateau continental sud-brésilien a été analisée envisageant la comparaison entre les attributs de l'assemblage soumis à la pêche chalutière aux crévettes, profondeur 10m, et ceux de l'assemblage d'une aire adjacente, profondeur 15m, où il n'y a pas ce type de pêche. Le matériel a été prélevé en utilisant le chalut de fond, années 1999 et 2000, et leur composition, abondance et activité reproductive ont été évaluées. Parmi les soissante-deux espèces de poissons,

30 ont été communes aux deux aires, 24 ont été exclusives de l'aire 10m, et huit de l'aire 15m. La pêche aux crevettes et son conséquent bycatch de poissons ont lieu dans une aire du plateau portant des attributs ichtyofaunistiques différents de ceux de l'aire voisine, surtout des valeurs plus importantes d'espèces exclusives, d'effectif numérique, d'activité reproductive et d'espèces ayant un interêt commercial. Les espèces ayant une bonne valeur commerciale quand les individus sont adultes (Clupeiformes et Sciaenidae) ont des abondances plus régulières au cours du temps à 10m qu'à 15m, où quelques groups sans interêt commercial (Haemulidae, Tetraodontiformes) sont plus abondants. Il est proposé que l'absence de pêche au chalut dans l'aire 15m ne peut pas réduire les impacts que cette activité cause dans son aire voisine.

MOTS-CLÉ: pêche, poissons, crévettes, bycatch, Brésil.

RESUMO

Ictiofauna demersal numa região de Plataforma Continental do Sul do Brasil, submetida à pesca camaroeira. A ictiofauna de uma região de Plataforma Continental do litoral do Paraná foi analisada objetivando comparar os atributos das espécies cujos indivíduos estão submetidos à pesca camaroeira com arrasto de fundo (profundidade 10m), com aqueles das espécies cujos indivíduos situam-se em área adjacente, sem atividade pesqueira (profundidade 15m). O material foi coletado através de arrasto de fundo, em 1999 e 2000, analisando-se sua composição, abundância e atividade reprodutiva. Entre as sessenta e duas espécies de peixes, 30 foram comuns às duas áreas, 24 exclusivas da área 10m e oito exclusivas da área 15m. A pesca camaroeira e seu conseqüente *bycatch* ocorrem numa área de Plataforma onde os atributos da ictiofauna são diferentes daqueles da área próxima. Incluem maior número de espécies exclusivas, maiores efetivos numéricos, maior atividade reprodutiva e espécies mais apreciadas para consumo. Os grupos cujos indivíduos são de bom valor comercial quando adultos (Clupeiformes e Sciaenidae) têm abundâncias mais regulares ao longo do tempo na área 10m que na área 15m; nesta, grupos sem

interesse comercial (Haemulidae, Tetraodontiformes) predominam. Conclui-se que a assembléia de peixes da área 15m, onde pesca não é realizada, não dispõe de atributos biológicos (composição, atividade reprodutiva e outros) que pudessem neutralizar os efeitos impactantes causados pelo bycatch da pesca camaroeira na área adjacente.

PALAVRAS-CHAVE: pesca, peixes, camarões, bycatch, Brasil.

ACKNOWLEDGMENTS — We would like to extend our gratitude to Dr F. P. Brandini, leader of the RAM/PADCT Project, and to all colleagues of the Laboratory of Estuarine Ichthyology.

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Recebido em 2.02.2003.