IMPACTED BIODIVERSITY BY INDUSTRIAL PIRAMUTABA FISHING IN THE AMAZON RIVER MOUTH

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ABSTRACT

In Brazil, industrial fishing of the piramutaba catfish is performed at the estuary of the Amazon River, utilizing bottom-trawl nets as equipment. This fishing technique is considered potentially the most harmful to the environment and to biodiversity, due to the destruction of biomes and incidental capture of several species, called "*bycatch*." In order to characterize the species which compose the ichthyofauna *bycatch* of the piramutaba catfish, we analyzed 459 fishing trawlers between the years of 2002 and 2008, in the allowed and forbidden areas. The results revealed that the ichthyofauna *bycatch* of the piramutaba consists of 38 species, divided in 33 genera and 17 families. The piramutaba was confirmed as the main species, consisting of 76% of the overall product, and the gilded catfish as the main *bycatch* species, consisting of 7.05% of the product. We have recorded the incidence of jewfish (*Epinephelus itajara*), which can be found in the International Union for Conservation of Nature list of critically endangered species. In despite the production was higher in the rain season than in the dry season, there was no statistical difference in the rate of biodiversity in different areas or periods.

Keywords: *Brachyplatystoma vaillantii*; Amazon estuary; bottom-trawl fishery; bycatch

BIODIVERSIDADE IMPACTADA PELA PESCA INDUSTRIAL DE PIRAMUTABA NA FOZ DO RIO AMAZONAS

RESUMO

No Brasil, a pesca industrial da piramutaba (*Brachyplastytoma vaillantii*) é realizada na foz do rio Amazonas e utiliza como apetrecho de pesca rede de arrasto de fundo, considerada a arte de pesca potencialmente mais danosa ao ambiente e a biodiversidade, devido a destruição de biomassa e captura acidental de várias espécies, chamadas de fauna acompanhante ou *bycatch*. Com o objetivo de caracterizar as espécies que compõem a ictiofauna acompanhante da *B. vaillantii*, foram analisados 459 arrastos de pesca entre os anos de 2002 e 2008 tanto na área permitida quanto na protegida. Os resultados revelaram que a ictiofauna acompanhante da piramutaba é composta por 38 espécies, distribuídas em 17 famílias e 33 gêneros. A piramutaba foi confirmada como espécie dominante, compondo 76% da produção dos arrastos, e a dourada, a principal espécie acompanhante com 7,05%. Foi registrado a ocorrência de mero *Epinephelus itajara*, que encontra-se na lista da União Internacional para a Conservação da Natureza de espécies criticamente ameaçadas de extinção. Apesar da produção ter sido maior no período chuvoso do que na estiagem, não houve diferença no índice de biodiversidade nas diferentes áreas ou períodos.

Palavras-Chave: *Brachyplatystoma vaillantii;* estuário amazônico; fauna acompanhante; pesca de arrasto de fundo

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INTRODUCTION

Brazil is the 27º world's largest producer of fish with a network of 300 industries involved in its many activities generating more than 800,000 direct jobs, a total income only in 2002 of $ 4.9 billion, the equivalent of 0.4% of the Brazilian GDP - PIB (Ministry of Fisheries and Aquaculture - MPA, 2010).

The state of *Para* is the second largest producer of national fish. Of all the species landed, piramutaba *Brachyplastytoma vaillantii* (Valenciennes, 1840) share is about 15% of the total production. A *B. vaillantii* is a freshwater catfish belonging to the family Pimelodidae. In northern Brazil, the species occurs mainly in the estuarine area and along the Solimões-Amazonas Rivers and its tributaries of muddy water (BARTHEM and GOULDING, 1997).

Besides from intensive fishing (multispecies artisanal fleet), industrial fishery of piramutaba accidentally catch other species, calls in range of accompanying fauna or *bycatch*. Several authors have reported that the diversity and proportion of this fauna varies between areas and periods of fishing, and huge quantities of it is discarded, impacting many groups of species and the ecosystem as a whole (ALVERSON *et al*., 1996; YE *et al*., 2000; STOBUTZKI *et al*., 2001a; STOBUTZKI *et al*., 2001b). A recent report from *Food and Agriculture Organization of the United Nations* – FAO (2009) estimates that the *bycatch,* as a whole corresponds to approximately 23% of disposal of the world and that these levels can be much higher when analyzing the specific fisheries. According to ALVERSON *et al*., (1996), 27 million metric tons of species retained in fishing gear are discarded on average annually worldwide. According to HALL (1999), this is one of the biggest problems nowadays when it comes to marine resources even with respect to the waste of protein through disposal of these species. It is for this reason that environmental managers currently have shown a constant concern in studies on the use of *bycatch* (ARAÚJO-JÚNIOR *et al*., 2005). Given the importance to fishing of the piramutaba on the national economy and the major impacts caused by this activity, the study aims to qualify and quantify the ichthyological biodiversity of *bycatch* of industrial fishing of the piramutabeira.

MATERIAL AND METHODS

The information on production and diversity of the *bytcatch* of industrial fishery of piramutaba were obtained from the project management of the Brazilian Institute of Environment and Renewable Natural Resources: "Biology and Fisheries of the Piramutaba coordinated by the Center for Research and Management of Fishery Resources of the North Coast (CEPNOR).

Description of the fishery

They were accompanied trawls over seven years (2002 to 2008) in monthly shipments with an average duration of 15 days by the industrial fleet of piramutaba that operates at the mouth of the Amazon River, opposite the Marajo Island between the Maguari Cape (00º15'N and 48º25'W) and the North Cape (01º42'S and 49º55'W) about 80 miles from the coast at depths between 7 to 20 meters com trawls bottom nets outboard of a vessel (Figure 1).

The fleet consists of vessels that have iron hull and average length of 22 m, engines with an average power of 375 HP, storage capacity between 35 to 60 t, range of 28 days/sea, being manned by 5 to 6 fishermen. The nets are used for bottom trawling using polypropylene thread 30/45, length 70 to 80 m, Opening 50 to 60 m and height of a net mouth of 6 m.

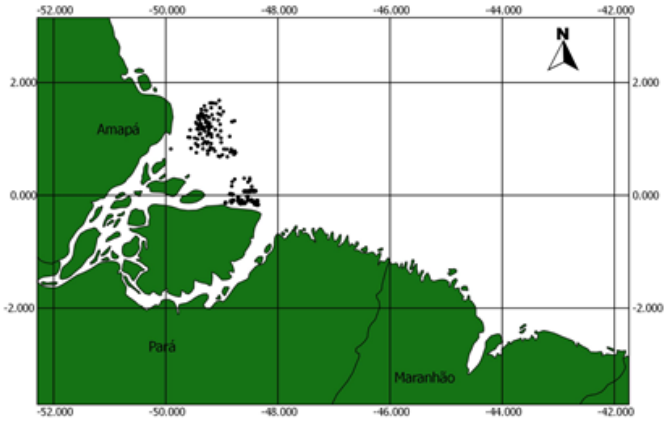


Figure 1. Points of data collection of *B. vaillantii* in industrial vessels at the mouth of the Amazon River during the years 2002-2008.

Collection procedures

During the shipments were analyzed two daily trawls, one during daytime and another at night. The distribution of trawls in the study area was made according to the preferences of commanders of the vessels without any interference from the Scientific Technician onboard.

After trawling, the Scientific Technician onboard filled three randomly baskets of 30 kg each with all species caught. In this sample, it was estimated the weight ratio of the piramutaba utilized (which attend market requirements in relation to size and condition) and rejected (in disagreement with market standards) and each species of *bycatch* utilized and rejected.

The data of the piramutaba and the *bycatch* species were properly recorded together with the following information for each trawl: identification of trawling, data, start and end time and end, fishing area (fisheries) latitude and longitude initial and final.

The samples were sent to the laboratory of Cepnor and species identified following specialized literature (FIGUEIREDO and MENEZES, 1979, 1980, 2000; CERVIGÓN *et al.*, 1992; IBAMA, 1998; SZPILMAN, 2000; SANTOS *et al.*, 2004), and subsequently confirmed by the website www.itis.org.

Data analysis

Data were digitized with free *software* and calculating the average frequency of total captured and unutilized in each of these groups was done using the formula proposed by TISCHER and SANTOS (2000):

$$F = (p/P) \times 100$$

Where:

p = Total biomass of the *bycatch* caught in all trawls / total advantage of the biomass of *bycatch* caught in all trawls;

P = Total number of trawls.

Still adopting the classification created by TISCHER and SANTOS (2000), each species was classified as *bycatch*: Very frequent (>70%), Frequent (70→30%), infrequent (30→10%) and sporadic (<10%).

For statistical analysis of the data was applied to analysis of variance (ANOVA) with 5% of significance between the means of the coefficients of proportionality capture (I/P) between the months and between the years 2002-2008. As the biodiversity index, the analysis used the Shannon test (*BioEstat* 5.3) to determinate differences between areas and periods, latter, the resampling was used to test the difference between the indices.

RESULTS

During the seven years of data analyzed were followed 458 trawls totalizing 1,030,678.50 kg of fish being 719,402.50 kg of fish utilized and 311,276.00 kg discarded. The ichthyofauna captured, besides the *B. vaillantii* were identified 38 fish species, distributed in 33 genera and 17 families (Table 1). The families with the greatest diversity were Pimelodidae with eight species and Ariidae and Sciaenidae each with seven species.

Table 1. List of ictiofauna bycatch of the industrial fishery for *B. vaillantii* between the years 2002-2008.

FAMILY	COMMON BRAZILIAN NAMES	SCIENTIFIC NAME *
Achiridae	Linguado	*Achirus lineatus* (Linnaeus, 1758)
Ageneiosidae	Mandubé	*Ageneiosus ucayalensis* (Castelnau, 1855)
Ariidae	Cambeua	*Hemiarius grandicassis* (Valenciennes, 1840)
	Jurupiranga	*Arius rugispinis* (Valenciennes, 1840)
	Cangatá	*Aspistor quadriscutis* (Valenciennes, 1840)
	Bandeirado	*Bagre marinus* (Mitchill, 1815)
	Uricica	*Catharops spixii* (Spix & Agassiz, 1829)
	Gurijuba	*Galeichthys parkeri* (Trail, 1832)
	Uritinga	*Sciades proops* (Valenciennes, 1840)
Aspredinidae	Viola	*Aspredo aspredo* (Linnaeus, 1758)
	Rebeca	*Aspredo sicuephorus* (Valenciennes, 1840)
Batrachoididae	Pacamão	*Batrachoides surinamensis* (Bloch & Schneider, 1801)
Centropomidae	Camurim	*Centropomus undecimalis* (Bloch, 1792)
Dasyatidae	Arraia bicuda	*Dasyatis guttata* (Bloch & Schneider, 1801)
Doradidae	Bacu	*Lithodoras dorsalis* (Valenciennes, 1840)
	Bacu	*Pterodoras granulosus* (Valenciennes, 1833)
Engraulidae	Sardinha	*Anchovia clupeoides* (Swainson, 1839)
Megalopidae	Pirapema	*Megalops atlanticus* (Valenciennes, 1847)
Mugilidae	Taínha	*Mugil curema* (Valenciennes, 1836)
Patamotrygonidae	Arraia	*Potamotrygon scobina* (Müller & Henle, 1841)
Pimelodidae	Filhote	*Brachyplatystoma filamentosum* (Lichtenstein, 1819)
	Barba chata	*Brachyplatystoma platynemum* (Boulenger, 1898)
	Dourada	*Brachyplatystoma rousseauxii* (Castelnau, 1855)
	Babão	*Goslinia platynema* (Boulenger, 1898)
	Mapará	*Hypophthalmus marginatus* (Valenciennes, 1840)
	Mandi	*Pimelodus altipinnis* (Van der Stigchel, 1946)
	Mandi	*Pimelodus blochii* (Valenciennes, 1840)
	Barbado	*Pinirampus pirinampu* (Spix & Agassiz, 1829)
Pristigasteridae	Sarda	*Pellona flavipinnis* (Valenciennes, 1836)
Sciaenidae	Pescada curuca	*Plagioscion surinamensis* (Bleeker, 1873)
	Cangauá	*Bairdiella ronchus* (Cuvier, 1830)
	Pescada amarela	*Cynoscion acoupa* (Lacépèce,1801)
	Pescada combuçu	*Cynoscion virescens* (Cuvier, 1830)
	Pescada gó	*Macrodon ancylodon* (Bloch & Schneider, 1801)
	Pescada corvina	*Micropogonias furnieri* (Desmarest, 1823)
	Pescada branca	*Plagioscion squamosissimus* (Heckel, 1840)
	Mero	*Epinephelus itajara* (Lichtenstein, 1822)
Sternopygidae	Itui	*Eigenmannia limbata* (Schreiner & Miranda, 1903)

* Names confirmed from www.itis.org.

Although the low occurrence in the bycatch of the piramutaba, highlights the mere (*Epinephelus itajara*) that is classified as Critically Endangered Species on the list of The International Union for Conservation of Nature – IUCN, and as endangered by overexploitation of The Red Book of Endangered Brazilian Fauna by the Ministry of the Environment – MMA (MMA, 2008).

Of the species of the ichthyofauna bycatch found, those known to have commercial value are: gilded catfish, goliath catfish, long-whiskered catfish, white mulle, acoupa weakfish, german salmon, South American silver croake, yellowfin river pellona and gillbacker sea catfish.

Of all the trawlings, the piramutaba corresponded to approximately 76% of fish caught reaffirming its importance as a target species. The ten species with higher productivity considering all trawls are listed above (Table 2). The Gilded catfish is the most productive species, representing 7% of all fish; being utilized in 92.59% of cases, which shows their great local economic importance.

Table 2. Species of *bycatch* with higher total productivity of the industrial fishing *B. vaillantii* in trawls monitored during the years 2002-2008 at the mouth of the Amazon River.

Species	Total Production		Exploited Production			Rejected Production		
	kg	Frequency	kg	%	Frequency	kg	%	Frequency
B. rousseauxii	72,661.00	VF	67,274.00	92.59	VF	5,387.00	7.41	S
C. virescens	32,160.00	VF	30,393.00	94.51	VF	1,767.00	5.49	S
P. scobina	44,699.00	VF	3,022.00	6.76	S	41,677.00	93.24	F
B. marinus	52,288.00	VF	50,980.00	97.50	VF	1,308.00	2.50	S
P. flavipinnis	4,511.00	F	3,099.00	68.70	F	1,412.00	31.30	I
L. dorsalis	6,814.0	F	545.00	8.00	S	6,269.00	92.00	F
A. quadriscutis	15,062.00	F	4,525.00	30.04	S	10,537.00	69.96	I
G. parkeri	6,757.00	I	6,722.00	99.48	I	35.00	0.52	S
H. grandicassis	3,778.00	S	808.00	21.39	S	2,970.00	78.61	S
P. squamosissimus	6,260.00	S	5,450.00	87.06	S	810.00	12.94	S

VF - Very Frequenty, F – Frequent, S – Sporadic, I - Infrequent

The catch of Sea Trout and South American silver croaker also showed high production corresponding to approximately 4% of the total catch. The raspy river stingray, despite being "very frequent" has a low exploited production: although present in 356 trawls was only possible in 31 throws.

The relationship between biomass *bycatch* and biomass of the target species shows up higher at the beginning of the year, with an average of 0,31 kg of the *bycatch* per kg of the piramutaba, with statistical differences between periods ($p<0,05$) (Figure 2).

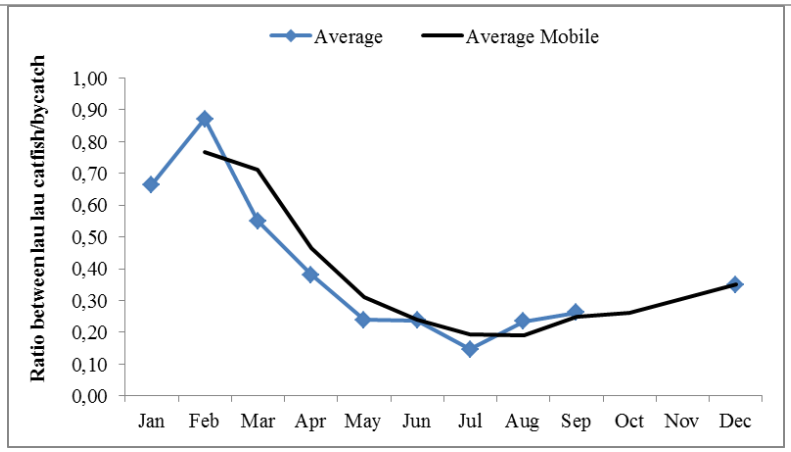
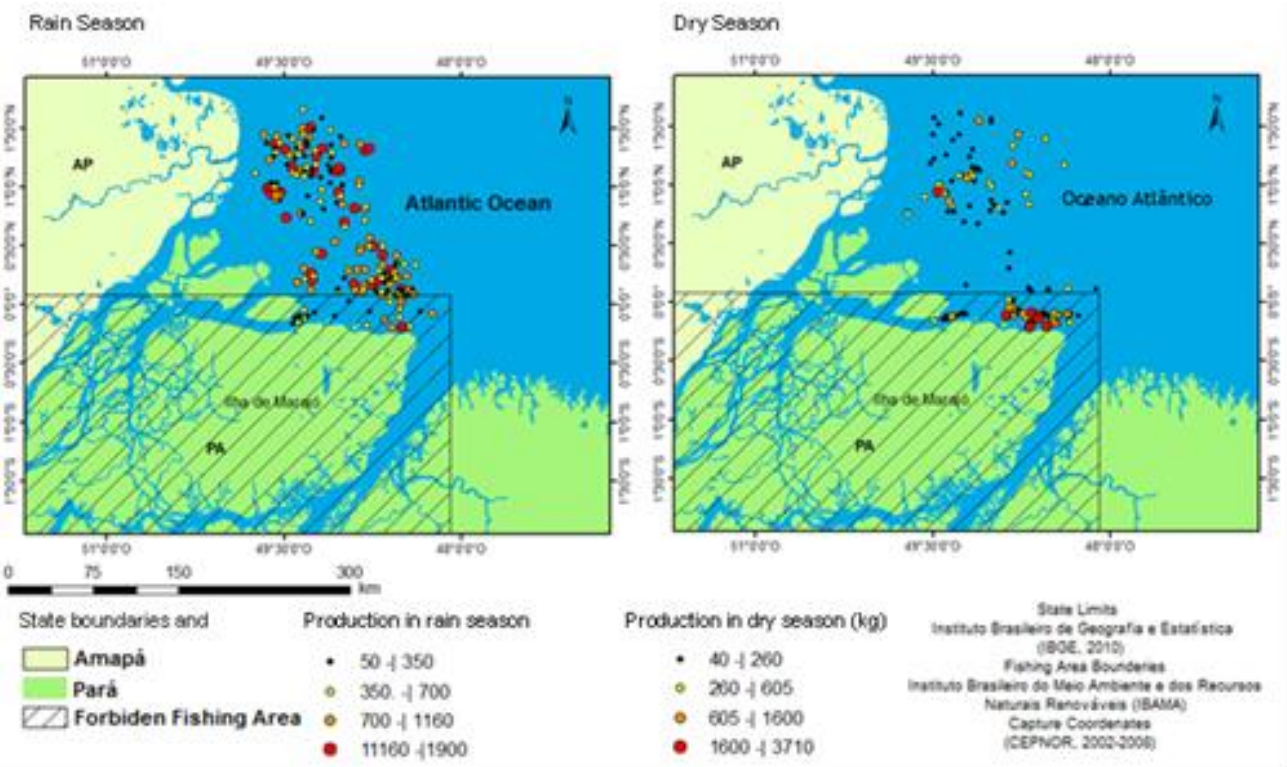


Figure 2. Monthly ratio of the *bycatch* per kg of *B. vaillantii,* caught by industrial fishing at the mouth of the Amazon River in the period 2002-2008.

The distribution maps between the areas evidences that the production and the biodiversity was higher in the allowed area during the rain season, however, during the dry season, the higher biomass and richness stays in the forbidden area, next to the Marajo coast (Figure 3). Considering the data was collected in industrial vessels, it can be implied that there is a regular capture activity in the forbidden area. However, the analyses showed no significant differences between the levels of biodiversity in areas (p: 0.52) or season (p: 0.52).



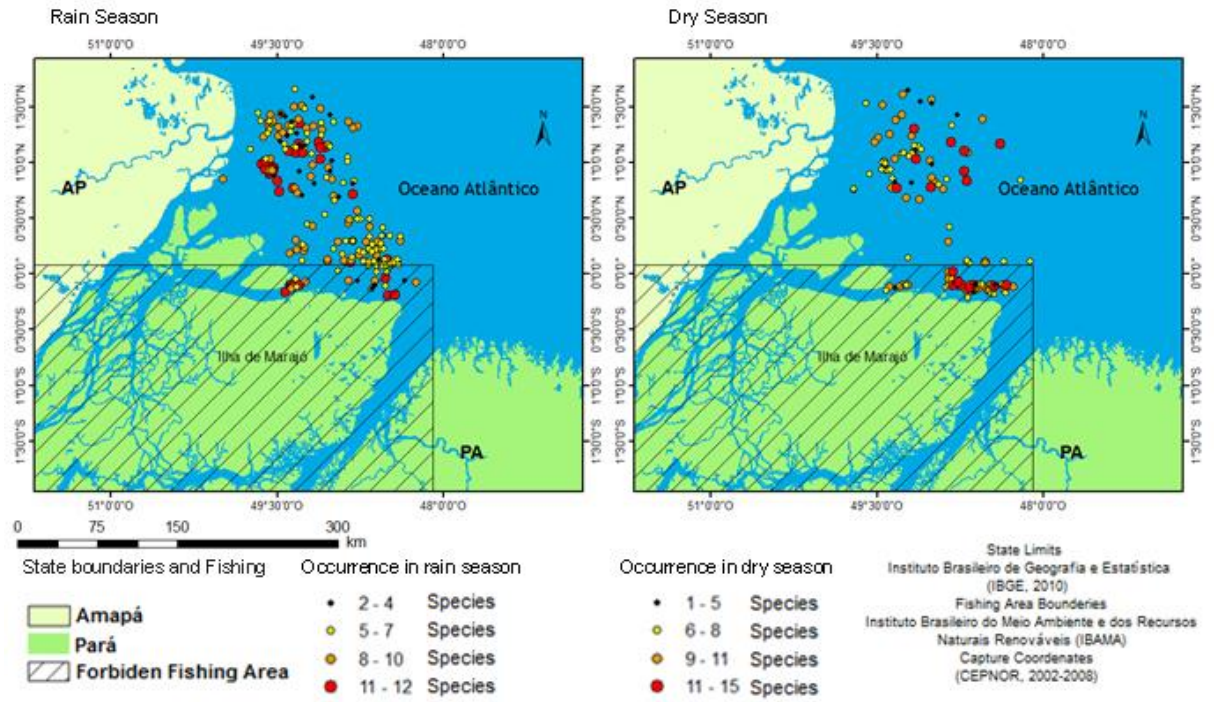


Figure 3. Distribution maps of capture and biodiversity per forbidden and allowed areas and rain and dry season.

DISCUSSION

The occurrence observed in our studies agree with PINHEIRO and FRÉDOU (2004) who identify that Pimelodidae, Ariidae, and Sciaenidae are the most frequent landings in the state of *Para*. The diversity in the *bycatch* identified also support the work of ISAAC (1998) which shows that they are usually found in almost all species of fisheries of the piramutaba: Thomas sea catfish, Bressou sea catfish, marine catfish, Brown sea catfish, gilded catfish, Sea Trout, and german salmon. PAIVA *et al.*, (2009) in study on *bycatch* of industrial fishing for pink shrimp *Farfantepenaeus subtilis* (Pérez Farfante, 1967) on the north coast revealed that the most productive the species german salmom fished and others including the aforementioned.

The high frequency of the gilded catfish in the *bycatch* of the piramutaba revealed in this study corroborates with OLIVEIRA *et al.*, (2007) who listed 38 fish species in the northern Brazilian coast, the species is one of the most frequently cited. CUTRIM *et al.*, (2001) in a study of catch composition in estuarine area rich in macroalgae, known as trash, also reveals a high frequency of catfish in the region. The high occurrence of the gafftopsail catfish in the *bycatch* of the northern region of the country has also been previously reported by PINHEIRO and FRÉDOU (2004).

On the other hand, SANYO-TECNO-MARINE (1998) registered the canguito *Arius phrygiatus* (Valenciennes, 1840) as the most frequent species in the region and this species was not identified in the present study.

The frequency of landings in the state of *Para* is derived from its low or high commercial value and lack of market. BARTHEM (1990) had already alerted to the occurrence of species with commercial interest in *bycatch*, such as the gilded catfish, suggesting its economic exploitation to reduce reject in industrial fisheries.

According to PAZ *et al.*, (2011) in a study on the market for fish of Vila do Conde/PA the gilded catfish has the third highest average sales

price and gross primary revenue, generating R$ 54,920.45 per year in commercial transactions being the most exploited species and ranked as the most important economically, which explains its high utilization rate in trawls. On the other hand, the raspy river stingray has a low exploited production, according to PAZ *et al*., (2011) in a study on fish landing in Vila do Conde, the average sales price for the same is only R$ 1.00/kg.

The relationship founded between biomass *bycatch* and biomass can be justified by the bottom-trawl fishery and natura/commercial aspects. BRANCO and VERANI (2006) in a study on the *bycatch* of the atlantic seabob shrimp *Xiphopenaeus kroyeri* (Heller, 1862) in Santa Catarina, reports that the use of bottom trawls in the fishery, generates an output of 0.4 kg of ichthyofauna *bycatch* for 1.0 kg of the target species, demonstrating that the same fishing gear in different fisheries, may cause volume identical to the *bycatch.* According to ISAAC *et al*., (1996) in a study on fishing activity in the region of Santarem the production is influenced besides the natural factors, social factors, such as economic interest and the consumer market.

The distribution map shows differences in dispersion when considered periods of drought and flood. According to CASTELLO (2007) organic production is related to complex biotic and abiotic factors, as physical oceanographic and climatic forces, inter-and intraspecific competition and other fisheries. Thus, the rainiest period of the year, the great flow of Amazonas projects fresh water at a greater distance from the coast water, allowing freshwater specimens that inhabit the innermost areas and fresh water of the estuary migrate to outer areas facilitating its capture by the industrial fleet, and increasing industrial landing.

Although the peak in the proportion of industrial fishing of the piramutaba is the beginning of the year, BARTHEM (2004), analyzing the artisanal landing of the market Ver-o-Peso in Belem, reports that this modality production peaks occur in the second half of the year (the dry season), period known as "summer harvest". Once during the dry season the coastal waters suffer less influence from spills of Amazonian rivers as piramutabas migrate to the coast, where the water is fresher to initiate the reproductive cycle (OLIVEIRA *et al*., 2007) enhancing the capture by artisanal boats.

These data reveal that the proportion of species of ichthyofauna *bycatch* captured remains constant over the years, according to OLIVEIRA *et al*., (2007) who studied the Amazon estuary fishing, showed that the species richness of fish did not change significantly during the study period.

CONCLUSION

New studies on how biotic and abiotic factors can interfere with productivity are necessary for explaining fluctuations in the proportion of the *bycatch* in the fishing for the piramutaba. Considering that the piramutaba are overfished and that gilded catfish has a high and constant production and high commercial value, it is proposed that a percentage of gilded catfish to be exploited by way of mandatory by the industrial fleet over the same percentage of the piramutaba, as a way to mitigate the impact on the target species.

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