SEASONAL DYNAMIC OF AMAZONIAN SMALL-SCALE FISHERIES IS DICTATED BY THE HYDROLOGIC PULSE

Raniere GARCEZ Costa Sousa[1], Lucirene Aguiar de SOUZA[2], Márcia Elane FRUTUOSO[3] Carlos Edwar de Carvalho FREITAS[2]

ABSTRACT

This study analyzed the dynamic of an Amazonian small-scale fishery, and as it is associated to the hydrological cycle. Landing data were daily collected from February/2007 to January/2008 at the Panairzinha harbor in Manacapuru city, Amazonas – Brazil (3º 18'33"S e 60º 33'21"W). The results showed that the active fleet in the Lago Grande consists of motorized canoes and fishing boats. The first group being greater than the second in number. The average of fish landed was 274.15 ton.year^{-1}. Occurring lower production in the hydrological periods of rising/flood and high production in the receding/drought. The main fish species landed were: *Colossoma macropomum* (tambaqui = 17.8%), *Cichla monoculus* (tucunaré = 15.5%), *Prochilodus nigricans* (curimatã = 12.2%), *Astronotus ocellatus* (acará-açu = 8.7%) and *Osteoglossum bicirrhosum* (arowana = 8.4%), where gillnets were predominantly (97%) in these catches. It was observed that the seasonality of the Solimões River, directly influences the fisheries and the availability of fish in the environment. In this sense, decisions involving fishing management of this region should be planned aiming to ensure the sustainability of local fisheries, considering as essential the relation between fish, the environment and the socioeconomic aspects inherent with these small-scale fisheries.

Key words: Fisheries landing; Panairzinha; artisanal fisheries; flood pulse; Central Amazon.

A DINÂMICA SAZONAL DAS PESCARIAS DE PEQUENA ESCALA NA AMAZÔNIA É DEFINIDA PELO PULSO HIDROLÓGICO

RESUMO

O presente estudo analisou a dinâmica de uma pescaria de pequena escala na Amazônia, em associação com o ciclo hidrológico. Dados de desembarque pesqueiro foram coletados, diariamente, no período de fevereiro/2007 a janeiro/2008, no Porto Panairzinha em Manacapuru, Amazonas – Brasil (3º 18'33"S e 60º 33'21"W). Os resultados mostraram que a frota atuante no Lago grande é composta por canoas motorizadas e barcos de pesca. Sendo o primeiro superior ao segundo em número. A média do pescado desembarcado foi de 274,15 ton.ano^{-1}. Ocorrendo uma menor produção nos períodos de enchente/cheia e maior na vazante/seca. As principais espécies desembarcadas foram: *Colossoma macropomum* (tambaqui = 17,8%), *Cichla monoculus* (tucunaré = 15,5%), *Prochilodus nigricans* (curimatã = 12,2%), *Astronotus ocellatus* (acará-açu = 8,7%) e *Osteoglossum bicirrhosum* (aruanã = 8,4%), predominando a malhadeira (97%) nessas capturas. Foi observado que a sazonalidade do Rio Solimões, influencia diretamente nas pescarias e na disponibilidade do pescado. Nesse sentido, decisões envolvendo o manejo pesqueiro nessa região devem adotar medidas que assegurem a sustentabilidade da pesca local, considerando como essencial a relação entre o peixe, o ambiente e aspectos socioeconômicos das pescarias de pequena escala.

Palavras chave: Desembarque pesqueiro; Panairzinha; pesca artesanal; pulso de inundação; Amazônia Central.

Artigo Científico: Recebido em 24/08/2016; Aprovado em 17/02/2017

[1]*Universidade Federal de Rondônia (UNIR), Departamento de Engenharia de Pesca. Rua da Paz, 4376 - Lino Alves Teixeira - CEP: 76916-000, Caixa Postal 32, Presidente Médici-RO, Brasil.*

[2]*Universidade Federal do Amazonas (UFAM), Departamento de Ciências Pesqueiras. Bloco da Faculdade de Ciências Agrárias - Av. General Rodrigo Otávio Jordão Ramos, 6200 - Coroado I - CEP: 69077-000, Manaus-AM, Brasil. E-mail: freitasc50@gmail.com (corresponding author)*

[3]*Universidade Federal do Amazonas (UFAM), Departamento de Ciências Agrárias. Bloco da Faculdade de Ciências Agrárias - Av. General Rodrigo Otávio Jordão Ramos, 6200 - Coroado I - CEP: 69077-000, Manaus-AM, Brasil.*

INTRODUCTION

The Amazon basin has approximately 20% of its territory formed by floodplain areas along the rivers (JUNK and HOWARD-WILLIAMS, 1984) forming *várzeas*, which are Amazonian areas seasonally inundated by the white water rivers (PRANCE, 1980), and igapós, defined as seasonally flooded areas occurring in the black water river regions, as Amazon water logged swamp forest (PRANCE, 1980), both composing very rich ecosystems that support complex trophic chain (LOWE-MCCONNEL, 1987). The high spatial heterogeneity and the seasonal dynamic are key factors that contribute to successful colonization of the Amazonian floodplains by several fish species, which use this environment as breeding, refuge and feeding areas (SOARES *et al*., 2014; HURD *et al*., 2016).

Aside this high fish diversity, floodplains are highly productive areas, which is a key factor to the existence of abundant fish stocks. Therefore, fishing becomes an important activity at the Amazon basin, in social, economic and ecological terms (FREITAS, 2002b). The fisheries and its related knowledge are transmitted by generations, permiting the use of fish resource from natural environment, and getting to riverine people a cultural background about the aquatic environment and its existent fish fauna (GOULDING, 1979; SOUZA *et al*., 2015).

Fish is the main animal protein source for the Amazonian people (FABRÉ and ALONSO, 1998; SANTOS and FERREIRA, 1999; GARCEZ *et al*., 2009; ISAAC *et al*., 2015), and also represents an important symbol for the regional culture (FURTADO, 1993), mainly for the riverine communities that have fisheries as the main labor activity (BARTHEM, 1999). PARENTE (1996) stated that are about 20.000 professional fishermen registered at the fishermen colonies, including the rural farmers that also works on fisheries, as subsistence or commercial activity. Thus, it's contribute to the permanence of riverine communities and guarantee in these areas a permanently occupancy (SANTOS and FERREIRA, 1999).

The commercial fishing production in the Amazonas State has in Manaus City (Capital State with an estimated population about 2 million habitants, IBGE 2016), the main landing Center (BATISTA et al., 2004), where are landed about 30,000 ton.year^{-1} (MERONA and BITTENCOURT, 1988; RUFFINO *et al*., 2006), contributing with 68.8% of total fish production in the State, followed by the municipalities of Tabatinga with 8.1% and Manacapuru with 6.6% (RUFFINO *et al*., 2006).

There are several studies on riverine fishing (FURTADO, 1993; RIBEIRO and FABRÉ, 2003; FABRÉ *et al*., 2007; BATISTA and PETRERE JR, 2007; GARCEZ *et al*., 2009; SOUZA *et al*., 2015) that showed that the riverine fishers developed a pool of fishing strategies to explore the aquatic resources (SOUZA *et al*., 2015). These people known the importance of water level dynamic, and classified than in two main seasons, as flood and drought periods, but they also includes two transitory seasons as rising water and receding water periods (FRAXE, 2004). Over an annual basis, the periods of hydrological cycle have not a marked division, since they cover each other going in and out in few days interval: rising water (January to April), flood (May to August), receding (August to October), and drought (October to November) (BITTENCOURT and AMADIO, 2007).

The fisheries activity in the Amazon basin could be divided in six categories: subsistence, commercial, industrial, artisanal, ornamental, and sportive (BARTHEM *et al*., 1997; SANTOS and FERREIRA, 1999). Nevertheless, at the lower Solimões River and its adjacent floodplain just two categories are predominant: the subsistence and small scale commercial fisheries, which both presents artisanal characteristics (RUFFINO *et al*., 2006; CAMPOS *et al*., 2007) and were responsible for 60% of fisheries production in the Amazon basin (BAYLEY and PETRERE JR., 1989).

The subsistence modality is made mainly by the riverine fishermen (97%), but in less proportion has been practiced too by the fishermen resident in the urban centers (GARCEZ *et al*., 2009). These fishermen groups acting in small-scale fisheries that are less professionalized (RUFFINO, 2004) using the propulsion motors (known locally as rabeta canoes) or paddle attached to their small boats. In general theses fisheries occurs closer to their residences (BARTHEM *et al*., 1997).

The small scale commercial fisheries (3%) is more professionalized (GARCEZ *et al*., 2009) attaining better fisheries structures in their boats, as icebox containers (storeroom capacity about 10 tons) for fish conservation and storage. Also, allowing a bigger crew onboard and can do meddle and large fisheries trip extending about 100 to 300 km, from their communities (BATISTA and PETRERE, 2007). These fish boats had success in their fisheries mainly when acts close or in the preserved areas, as occur in the Manacapuru Lago Grande System (GARCEZ and FREITAS, 2011), but nowadays this proceeds started to reflects the existence of some fish stocks depletions in the Amazon basin (AGOSTINHO *et al.*, 2007; GARCEZ and FREITAS, 2011; CAMPOS *et al.*, 2015) which is clearly viewed from the decreasing of target fish number landed in the urban centers, which forces the fishermen to figure out fisheries in remote fish zones (BAYLEY and PETRERE JR., 1989; BATISTA and PETRERE, 2007).

In this context, is noticed that the success of fisheries management plans depends equally to know about the cultural and environmental conditions from the resource users, thus to consider a successful fisheries management plan, its need to be incorporates the human and environmental dimensions as an integrative strategy (AGOSTINHO *et al.*, 2007). In this way, the present research intends to verify the influence of Solimões River water level variation on the fisheries production that is landed in the Panairzinha harbor at the Manacapuru municipality, in order to estimate the local fishery fleet production and its relation with the seasonal hydrological season at the middle Amazon River region.

METHODS

Study area

The present study was conducted at the Lago Grande region in Manacapuru municipality, located at the confluence of Solimões River with the mouth of Manacapuru River (3º 18'33"S e 60º 33'21"W) (Figure 1). In this region, the Solimões River presents a seasonal water level variation and its normal amplitude changes over the hydrologic cycle attaining close to 10 m, and its imply in periods of flood and drought well defined (BITTENCOURT and AMADIO, 2007; GARCEZ and FREITAS, 2008). This inundation periodicity contributes with a complexity aquatic environments (streams, channels, water corridor, lakes, and swamps), which connects or put apart its selves during the hydrologic cycle periods, forming a huge floodplain ecosystem (JUNK, 1997; HURD et al., 2016). This region aggregates a large variety of resident and migratory fish species (FREITAS and GARCEZ, 2004), and its diversity have been attractive for the establishment of human riverine communities (MÓRAN, 1990) that also exploit this natural fish resource by an artisanal subsistence and small-scale commercial fisheries activity.

Sampling data

The fishing dataset were collected daily from February 2007 to January 2008, at the Panairzinha fish landing harbor in the Manacapuru municipality (Amazon State - Brazil). The data collections were processed applying a structured questionnaires (LAKATOS and MARCONI, 1991), joint to the fishermen and fish boats owners, these interviews were done at the fish landing moment, using queries related to fishing grounds, number of individuals in the crew, target fish species, fishing gears, total fishing production (kg), fishing boats as classified by BATISTA (2003) and fishing production by season of the hydrologic cycle following BITTENCOURT and AMADIO (2007). Also, fish species were identified according to the key proposed by FERREIRA et al. (1998) and by specialists. The Solimões River water level values were conceded from the National Water and Electrical Energy Agency (ANEEL - www.aneel.gov.br). All data set were organized electronically in tables for posterior statistical analysis.

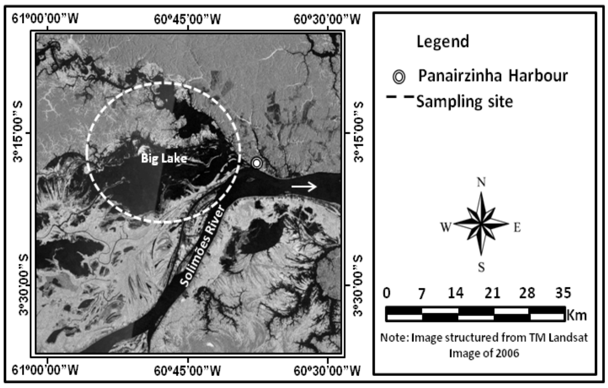

Figure 1. Study area locality identified by the dot line. The arrow indicates the Solimões River water flux direction.

Statistical analysis

The data set were submitted first to the descriptive statistic, in order to calculate the values of mode, mean, standard deviation and frequencies. Afterward, the data were used in two-dimensional graphs in order to understand the seasonal behavior of fishing landings.

The boats productivity and frequencies values were submitted to the Pearson analysis to verify possible correlation between these variables with the fluctuations of the Solimões River flood pulse. Fish landing by species and by types of fishing gears were employed to the Correspondence Function Analysis (GOTELLI and ELLISON, 2011) to verify the existence of patterns in relation to the hydrological cycle (rising, flood, receding and drought periods). All statistical analyses were performed using the Statistic 9.0 software (STATSOFT, 2009) assuming an inferior probability of *p-value* < 0.05 to reject the null hypothesis (CONAGIN *et al*., 2008). The Amazon Federal University ethical committee approved this research (license number 0001.0.115.000-08).

RESULTS

Small-scale fisheries fleet

A total of 823 questionnaires were applied to fishers at the Panairzinha fish-landing harbor. The data set allowed us to identify two types of boats employed by the fishing fleet at the Lago Grande area: motorized canoes (N = 798) and fishing boats (N = 25). Following BATISTA (2003), the fishing fleet was divided in small (<10 m or 32 ft) and large sizes (>10 m or 32 ft) boats. The small motorized canoes were predominant in number, grouping at the size modal class of 6-8 m or 19-26 ft (96%), while the fishing boats were considered in general as large size, attaining the modal size class of 8-14 m or 26-45ft, representing 2% of the total boats observed during the study (Figure 2).

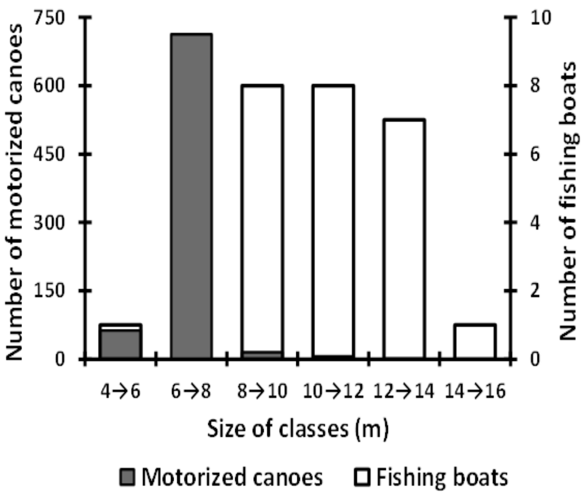

Figure 2. Size class frequencies of boats that fishing at the Lago Grande region at the Manacapuru municipality.

Crew, engines potency and fishing gears

The average of fishers on board of fishing boats was of 1.91 ± 0.73 for canoes (maximum of 6 persons) and 3.96 ± 1.68 for fishing boats maximum of 9 persons). There were a positive relation between the number of fishers and boat sizes, but this linear relation were weak, for both types of fish boats, as showed by the correlation coefficient with values of $r^2 = 0.019$ ($p < 0.001$) for the canoes and $r^2 = 0.137$ ($p = 0.062$) for the boats, respectively. The motorized canoes (N = 798) generally were coupled to engine horse power varying between 4 to 10 hp, with a modal class about 6 hp - 72.56% of the total sampled, and the fishing boats (N = 25) were attached to an engine hp varying between 4 to 30 hp, with a modal class about 25 hp representing 28% of the total. The capacity of fish storage (thermal box) was only available for motorized canoes that varying between 0.1 to 2.0 ton. Furthermore, was observed that in the large fishing boats, the fish production were saved in styrofoam box with capacity between 75 to 120 kg (each) organized in an stacking box area.

Each crew realized from 1 to 5 fishing trips per month, spending from 1 to 16 days (the fishing duration was dependent of fishing ground distance from the riverine communities and for the fish accessibility) corresponding to a fishing productivity varying from 0.05 to 0.9 ton.fisher^{-1}.day^{-1}. In the Lago Grande fisheries, the gillnet (meshing in size between 10 to 120 mm opposite knots, predominantly the groups of nets with mesh sizes of 70 mm (23,08%), 45 mm (18,80%) and 80 mm (17,45%), each net with an average standard size of 100 m in length (84,81%) and 4 m height) was the most frequent fishing gear (97%) and present in all hydrological seasons, followed by artisanal harpoons (1%) and others types of fishing gears (arch and arrow, hook and line) that corresponded to less than 2% of the total reported.

The monthly-average fishing production landed at the Panairzinha harbor, during the study period, was 22.85 ± 11.47 ton (equivalent to 58,548 m^2 of gillnets mesh applied in the fisheries), corresponding to 274.15 ton.year^{-1}. The Lago Grande fisheries production exhibited an oscillation that followed the seasonal water level fluctuation, presenting a decreasing production in the beginning of rising waters period (14.40 ton in February) and were falling until the end of flood period (11.66 ton in July). Afterward, the fishing production started to increase until the beginning of the drought season, when become more evident (45.76 ton in October). After that the fishing production was decreasing again until the beginning of flood period (25.48 t in January of 2008) (Figure 3A). Was noticed as well that the number of fish boats fishing at the Lago Grande fisheries also presented a seasonal pattern similar to the fishing production (Figure 3B), displaying a positive linear relation between the number of boats and the fisheries production with value of $r^2 = 0.912$.

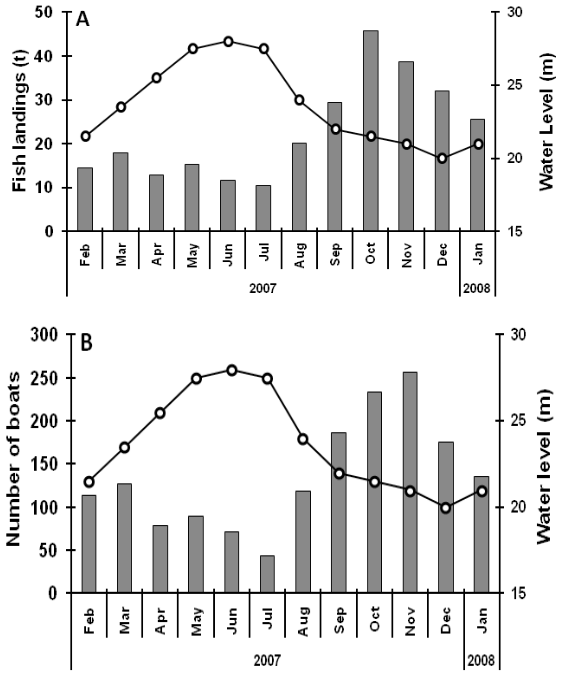

Figure 3. Month water level at the Solimões River and its relation with fishing production (A) and number of fishing boats (B) at the Lago Grande of Manacapuru.

The fishing production and its respective frequencies of boats registered at the Panairzinha harbor, exhibited a inverse pattern in relation to the Solimões River water level, presenting an inverse linear relationship (central values) with $r^2 = 0.543$ and 0.620, respectively (Figure 4A and 4B).

Seasonal fish species landed at the Panairzinha Harbor

During this research were observed 3,828 fish landed at the Panairzinha harbor, which were identified the most belonging to the Orders the Characiformes (48%), Siluriformes (28%) and Perciformes (12%). The Characiformes was the base for the fisheries occurred at the Lago Grande system at the Manacapuru municipality. From these fish orders were identified 25 species, bring to light the five most important species reported during the study period, in the following importance sequence (relative frequency = %): *Colossoma macropom* Cuvier 1816 (tambaqui) with 17.8%, *Cichla monoculus* Spix, 1831 (tucunaré) with 15.5%, *Prochilodus nigricans* Agassiz, 1829 (curimatã) with 12.2%, *Astronotus ocellatus* Cuvier, 1829 (acará=açu) with 8.7% and *Osteoglossum bicirrhosum*, Cuvier, 1829 (arowana) with 8.4% of the total fish landing at the Panairzinha Harbor (Table 1).

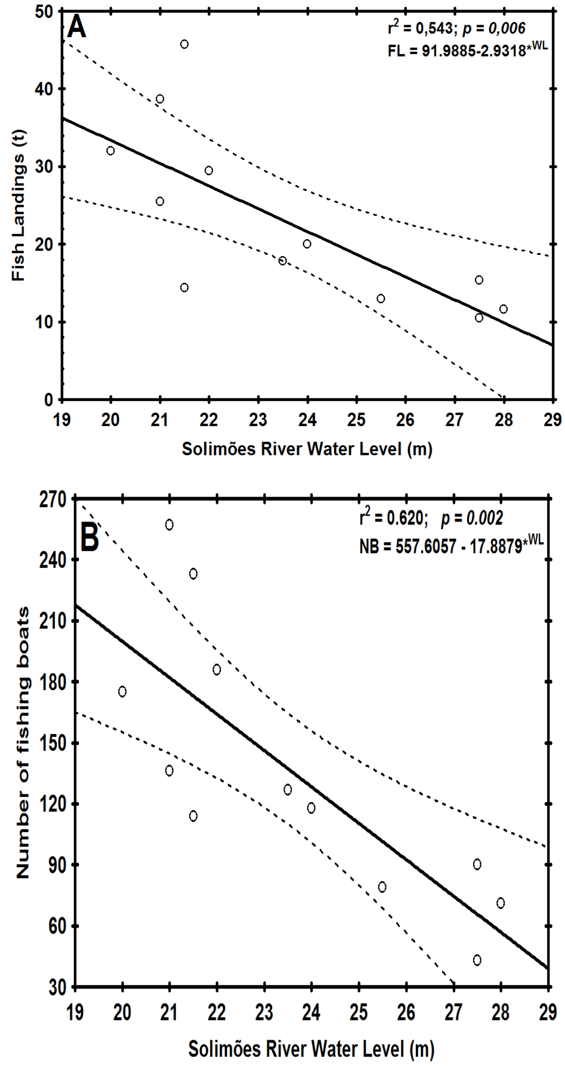

Figure 4. Linear analysis between the fishing production (fish landings - FL) (A) and the number of fishing boats - NB (B) as function of Solimões River water level. Dotted lines represent Confidence Interval = 0.95.

The correspondence analysis exhibits in the dimension-1 (Eigenvalue = 0.08798; inertia = 60.75%) the influence of hydrological cycle. In the left side of the graph were plotted the fish species caught during the rising (R) and flood (F) periods, while in the right side were plotted the others species caught during the resending (Re) and drought (D) periods, respectively (Figure 5). The dimension-2 (Eigenvalue = 0.03884; inertia = 26.82%) also distributed the hydrological variables in opposite sides, showing an inverse clockwise sequence. In the same time both dimensions separated in opposite angles the transitional (Rising, Receding) and the well-defined seasonal periods (Flood, Drought).

The fish species also were grouped in each axis according to their interaction with the water level variation. In the dimension 1 (right side) stayed separated the fish species caught during the drought season (D). These fish species are typical from lakes environment, with one exception that was the surubin (Sur), which develop short migrations between the lake and the river channel. Also in the right side of the graph (inferior part), were located the fish caught during the receding waters (Re). In the left side of the bi-plot with Correspondence Function Analysis (CFA) result were grouped the fish species caught throughout the rising period (R) represented by migratory species and by two sedentary fish: acará-açú (Car) and piranha cajú (Pic). Also in the left side and inferior part of the graph, were clustered the fish caught during the flood period, which are migratory fish species characteristics from river channel areas (Fig. 5).

Table 1. Seasonal absolute and relative frequencies of fish species landed at the Panairzinha harbor in Manacapuru municipality (Amazon-Brazil).

Taxon	Fish code	Commum name	Fish landing frequencies				
			Absolute (Seasonal)				Relative (% Year)
			**R	F	Re	D	
Clupeiformes							
Pristigasteridae							
Pellona flavipinnis (Valenciennes, 1837)	Ap	Sardinhão	4	1		1	0.2
Osteoglossiformes							
Arapaimidae							
Arapaima gigas (Cuvier, 1829)	Pira	Pirarucu	5		19	14	1.0
Osteoglossidae							
Osteoglossum bicirrhosum (Cuvier, 1829)	Aru	Aruanã	85	67	115		8.4
Characiformes							
Anostomidae							
Leporinus friderici (Bloch, 1794)	Ar	Aracu	36	46	8		2.4
Characidae							
Triportheus angulatus (Spix & Agassiz, 1829)	Sar	Sardinha	13	4	5	2	0.6
Piaractus brachypomus (Cuvier, 1818)	Pt	Pirapitinga	42	38	14	18	2.9
Curimatidae							
Potamorhina latior (Spix & Agassiz, 1829)	Br	Branquinha	13	9	6	2	0.8
Cynodontidae							
Rhaphiodon vulpinus (Agassiz, 1829)	Pca	Cachorro	2	1	1		0.1
Briconidae							
Brycon amazonicus	Mat	Matrinchã	5	19	2		0.7
Erythrinidae							
Hoplias malabaricus (Bloch, 1794)	Tra	Traira	41	20	12	33	2.8
Prochilodontidae							
Prochilodus nigricans (Agassiz, 1829)	Cur	Curimatã	183	133	60	90	12.2
Semaprochilodus spp.	Jar	Jaraqui	35	46	4	2	2.3
Serrasalmidae							
Colossoma macropomum (Cuvier, 1816)	Tam	Tambaqui	156	195	187	145	17.8
Mylossoma duriventre (Cuvier, 1818)	Pac	Pacu	137	81	29	27	7.2
Pygocentrus nattereri (Kner, 1858)	Pic	Piranha cajú	134	91	26	46	7.8
Siluriformes							
Doradidae							
Anodoras sp.	Ba*	Bacu				1	0.1
Oxidoras niger (Bleeker, 1862)	Cui	Cuiu-cuiu	9	3	5	20	1.0
Hypophthalmidae							
Hypophthalmus fimbriatus (Kner, 1858)	Map	Mapará	3	1			0.1
Loricariidae							
Pterygoplichthys pardalis (Castelnau, 1855)	Bd	Bodó	16	10	8	19	1.4
Pimelodidae							
Brachyplatystoma flavicans (Castelnau, 1855)	Do	Dourado	1	8	2	1	0.3
Pseudoplatystoma tigrinum (Valenciennes, 1840)	Sur	Surubim	5	16	16	39	2.0
Phractocephalus hemioliopterus (Schneider, 1801)	Pir	Pirarara			2	1	0,1
Perciformes							
Cichlidae							
Astronotus ocellatus (Cuvier, 1829)	Car	Acará-açú	157	66	36	75	8.7
Cichla monoculus (Spix, 1831).	Tuc	Tucunaré	196	164	68	164	15.5
Sciaenidae							
Plagioscion squamosissimus (Heckel, 1840)	Pes	Pescada	42	30	21	59	4.0

* Fish species had not being considered in the Correlation Analysis because presented just one specimen in the samples. **R = rising, F = flood, Re = receding, and D = drought.

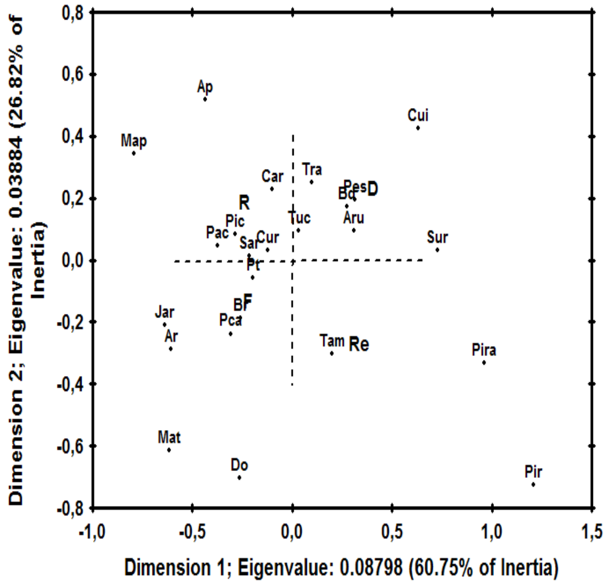

Figure 5. Fish species landed at the Panairzinha harbor in Manacapuru, and its seasonal caught periods organized by the Correspondence Function Analysis. R = rising, F = flood, Re = reseding, D = drought, Ap = Sardinhão, Pira = Pirarucu, Aru = Aruanã, Ar = Aracu, Sar = Sardinha, Pt = Pirapitinga, Br = Branquinha, Pca = Cachorro, Mat = Matrinchã, Tra = Traira, Cur = Curimatã, Jar = Jaraqui, Tam = Tambaqui, Pac = Pacu, Pic = Piranha caju, Ba = Bacu, Cui = Cuiu-cuiu, Map = Mapará, Bd = Bodó, Do = Dourado, Sur = Surubim, Pir = Pirarara, Car = Acará-açú, Tuc = Tucunaré, and Pes = Pescada.

Fishing costs

All fish caught during the study period were organized in ice and fish layers on the proportions of 1:1, 1:2 and 2:1 (ice:fish), and storage in thermal box coupled in the boats, but some time the fish were luggage also (when fisheries occurred in short period of time) in the canoes floor compartment. The fisheries productions were in its totality transported from the local communities boats, landing its production at the Panairzinha harbor to commercialization.

Theses fisheries costs were increased mainly by two reasons: the acquisition of fuel, that was the highest priced product for the fisheries expeditions (as mentioned by the fishermen), and varied from R$ 1.90 (US$ 0.89) to R$ 4.60 (US$ 2.16) per liter; also the cracked ice, elevated the fisheries costs and varied in price from R$ 1.00 (US$ 0.46) to R$ 3.00 (US$ 1.41) per container (20 liters volume). Each fisheries production proportionate an income between R$ 305.32 (US$ 143.34) to R$ 750.58 (US$ 352.38) per canoes and fish boats crew, respectively. The fisheries products price values corresponded to the study period, when the minimum salary was about R$ 380.00 or US$ 178.40 (Ordinary Law #11.498/2007, published in 06/28/2007), and in the study period, one United States dollar (US$ 1.0) was valuated in R$ 2.13.

DISCUSSION

The Amazon floodplain areas form a large and complex aquatics systems which attain over than hundreds of kilometers in extension and represents one of the most important macrohabitats for commercial and subsistence fisheries activities, that explore this region using paddle or motorized wood canoes supplied with fish traps (BARTHEM *et al.*, 1997). This fisheries became the main economical activity for the Amazonian riverine communities (GAWORA, 2003; PETRERE JR. *et al.*, 2004) and makes these people dependents of fish stock existent around their communities (GARCEZ *et al.*, 2009).

This artisanal fisheries pattern was confirmed in the present research by two types of embarkations utilized by the fishers in the study area, motorized canoes and fishing boats. The first group (small size canoes extending < 10 m) was predominant in numbers representing 97% of the fish boats catalogued. This finds differ from the results reported by BATISTA (2003) about the fish boats used in the fishing fleet of Itacoatiara, Parintins and Manacapuru municipalities. Also differing from the results found by GONÇALVES and BATISTA (2008) that identified the existence of four types of boats utilized by the fishing fleet from Manacapuru municipality. These differences in number of boats could be related to the large number of landing fish harbor sampled by the authors, in comparison with one from the present study. Also this lower fish boats divergence maybe a consequence of the fishing fleet modality recognized as small-scale fisheries as reported by GONÇALVES and BATISTA (2008) and by CARDOSO and FREITAS (2012) for the Amazon region.

Also the present study shows that motorized canoes (with 4 to 10 horse power engine) in general has on board or attached a thermal box (capacity box between 0.1 to 2 ton) for fish storage, this characteristics were similar from the results found by FALABELLA (1985) for fishing fleet observed in the same region. Furthermore, was observed that in the large fishing boats (size > 10m or 32 ft), the existence of two areas, one available for fish storage as stacking box space, and the other reserved for the crew accommodation (BATISTA *et al.*, 2004). The fluctuations in the production and fishing effort (considered in this work as the number of boats) depending on the fluctuation in the water level, which also have already been reported before by others studies in the Amazon basin (JUNK *et al.*, 1989; MERONA and GASCUEL, 1993; RUFFINO and ISAAC, 1994). The pattern of increase in the fisheries effort during the drought shows contrary to results observed by CARDOSO and FREITAS (2007) which found that fishing intensifies with the elevation of Madeira River water level, also noticed by FALABELLA (1985) and GANDRA (2010) which found the same increasing behavior for fisheries landed in Manaus.

These differences in fisheries production patterns probably occurs due to fisheries preferences for species which occurs during receding and drought, that is turned in the region for catfish, sedentary fish and some migratory fish as tambaqui. The number of fishing boats also fluctuates seasonally, however in reverse pattern as observed in the lower Amazon River, where the commercial fleet operates mainly during the flood period acting in the lakes, while throughout the drought the fisheries occurs preferably in the river main channel(SANTOS and SANTOS, 2005; CARDOSO and FREITAS, 2007).

The fishing fleet from Lago Grande system, in general performed their fisheries close to their local communities (GARCEZ *et al.*, 2009). But the extras boats accommodations for fish storage and crew, allowed the fishermen to effectuate long distance fisheries, as that fisheries sectors outside of Manacapuru municipality (GONÇALVES and BATISTA, 2008). These fisheries enlarged area, also were noticed by BATISTA (2003) from local fleet, which realized fisheries also in the Solimões-Amazonas River tributaries, as Purus River from Manacapuru fishing fleet and Madeira River visited by the Itacoatiara municipality fisheries fleet.

The actual small scale fishing fleet operating in the Amazon basin is in conformity with environmental diversity, once the boats structure and sizes permits fishers to navigate into the inhospitable and wild flood forest to catch their fish. Further, the fish resources have its behavioral presence or absent in these aquatic habitats entirely associated to the rivers flood pulse phenomena (HURD *et al.*, 2016).

Controversially, large boats as exist in the industrial fisheries are not allowed to navigate in interior areas once its huge sizes, make economically enviable to explore the shallow floodplain areas for fisheries activities, but this fisheries modality occur predominantly in the Amazon River estuary, acting mainly on the exploitation of catfishes (BATISTA et al., 2004).

Therefore, in this point of view, the fishing boats structural model is an important factor to be considered when fisheries trip decisions are made, mainly when taking into account long distance trips. However, also others factors as the size (number of people) of the crew on board, fish storage box capacity, fisheries duration, fishery cover area, and seasonal river water level variation, are decisive parameters to get success in Amazonian fisheries procedure.

The elevated number of individuals evolved in the fisheries activity can raise the activity cost, mainly in long distance fisheries. In the present study the average number of crew by fisheries were two people per canoes and a maximum of nine people per fishing boat, integrated mainly by colleague's participants and in less proportion by autonomous (BATISTA *et al.*, 2007). On the other hand, this result showed a lower crew size when comparing the results found by BATISTA *et al.* (2010) from the fisheries fleet occurred at the Piagaçu-Purus Reserve, which presented a crew size varying between 7 and 15 fishermen per fish boat. But, shows also a similar result ($n \approx 2$) when put in contrast with the values found by GARCEZ *et al.* (2009) that reports a average number about 3 fisherman per fishing excursion of 5 days duration.

The differences between the numbers of crew applied in the fisheries cited above may be a result of differences methodology applied to get the fisheries data set, and related to size of the boats utilized in the fisheries activities. Which in accordance with CARDOSO *et al.* (2004) its can present a straight proportional relation, as showed in his study from the fisheries fleet that landed its production in Manaus city (Amazon State), that reported an average of 5, 8 and 14 people per boats, considering its sizes as small (≤ 10m), middle (>10 to 20m) and large (> 20m), respectively. Also our results showed a positive relation (but weak, $r^2 < 0.2$) among these variables, represented by an average of 1.91 people per canoes (small sizes) and 3.96 people per fish boat (middle sizes).

Besides, the Solimões River water level seasonality is noticed by fishermen that developed many fisheries strategies adaptive to the flood pulse, and its confirms that the fishermen has a high level of traditional knowledge related to fish ecology, its aquatic environment, and know which trap need to be used to catch their prey (SANTOS *et al.*, 2016). This also can be confirmed throughout the multiple types of fishing gears utilized during the fisheries to catch a large diversity of fish, which are found in different aquatic environments (BATISTA *et al.*, 2004; CARDOSO and FREITAS, 2007; GARCEZ *et al.*, 2009).

The main fish trap utilized in the fisheries in the Amazon basin is the gillnet (PARENTE, 1996; CARDOSO *et al.*, 2004; FERNANDES *et al.*, 2009), also confirmed in the present study with a high frequency of 97% in the fisheries realized by the small fish boast (motorized canoes). The use of gillnet in fisheries has increased due to its high caught power and versatility, and this characteristics aggregates surpass from fisheries production which are commercialized in the riverside communities (PETRERE JR. *et al.*, 2004).

Small scale fishers also know about the river water level pattern, and they have a comprehension that the Rivers flood pulse is the main structural factor that controls the aquatic biota (GARCEZ and FREITAS, 2008) and this knowledge influence the fishermen to take decision about when, where and how to acts in their fisheries (SOUZA *et al.*, 2015; SANTOS *et al.*, 2016). Our results emphasized this affirmation when exhibit the rinsing in boats frequencies values and fisheries production that were proportionally inverse with the Solimões River water level, presenting a linear relation (r^2) of 0.62 and 0.54, respectively.

The fishing boats geographical and temporal distribution demonstrated that the small scale fishing fleet acts at the Lago Grande system specially during the end of the receding waters until the drought periods, realizing fisheries with duration about two days, its legitimates the results presented by CARDOSO (2005), GARCEZ and FREITAS (2008) and GARCEZ *et al.* (2009) in studies about fisheries executed in the same region, these authors concluded that the fisheries production rising occurs mainly in the drought period, when the aquatic environment become reduced in area and its makes the fisheries easiest to be done.

On the other hand, during the rising and flood periods the fisheries productions decline, it may be happened because the fish school leave the river channel and marginal lakes and goes into the direction of the floodplain areas doing a lateral migration (FERNANDES, 1997), and this fish movement behavior makes the fisheries difficult to be performed, once increase its effort and cost (CARDOSO and FREITAS, 2007; GARCEZ *et al.*, 2009).

The monthly fisheries production landed at the Panairzinha harbor during the study period was around the average of 22.85 ± 11.47 ton. This result is lower than those found by BATISTA (1998) when analyzed the fisheries production landed in Manacapuru, during the years of 1996 and 1997, and presented a monthly fisheries production around the average of 35 ± 8.2 ton. Also ours results show lower fisheries production values when compared to the fisheries results found by GONÇALVES and BATISTA (2008) in the years of 2001 and 2002 in the same region that registered an average production around 173 ton $month^{-1}$. These differences in fisheries production may be also a result of different numbers of sampling sites and periods from these studies, once the two first studies sampled data from one location per research (the first in Manaus city near to Manacapuru, and the second located in a port at the municipality object of this study), while the third made its sampling data in all fishing landing harbors in the Manacapuru city. But, it is important to emphasizes that the different methodologies presented from above studies, are not enough to justify these discrepancies among fish productions, and the reduction of the fish stock is a hypothesis that needs to be considered carefully in this fishery prospect.

The temporal distribution of fisheries landing by species were more cleared in the CFA analysis results, that exhibited a fish species frequencies associated with the seasonal hydrology of the Solimões River, which emphasized mainly the separation between the migratory and sedentary behaviors fish groups. The fisheries dataset from the rising and flood periods are in agreement with the results reported by FALABELLA, (1985) and by GANDRA (2010) for fisheries landed in Manaus city, which show that in those two periods occurs the highest amount of Characiformes migratory species, reporting that most of its fish species are from fisheries carried out in the Solimões River and its tributaries (PETRERE, Jr., 1985), where probably also comes from catches of Manacapuru region. At the receding period occurs the second fisheries peak generated by the increased productivity of the fisheries in the Lakes (FALABELLA, 1985), which explains the sedentary species and catfish found in the present analysis.

This seasonal pattern confirmed that the fish species adaptability with the aquatic ecosystems, and also indicates a high knowledge level from the riverine fishermen about both, fish and aquatic environment. This affirmative also were reflected from the recognition of fishermen fish traps diversity used during their fisheries activity, in response to the fish species diversity and the distinct environmental characteristic existent at the Amazon region (BATISTA *et al*., 2004; SOUZA *et al*., 2015; SANTOS *et al*., 2016).

In the Amazonian floodplain the fisheries intensities occurs in concordance of the regional communities culture and their consumption needs (GONÇALVES and BATISTA, 2008) these aspects reflects in the rising or declining in fisheries effort, mainly on the fish species with higher commercial valor. This affirmation was intensified mainly when compared the fish list landed at the Manacapuru from the years of 2001 and 2002 (GONÇALVES and BATISTA, 2008) beside to the present results, where are observed a reduction of fish species landed, from 35 to 25 fish species, from both studies respectively.

This results shows that the greatest number of fish species commercialized in Manacapuru belongs to the Characiformes Order, that are predominant in the experimental and artisanal fisheries occurred in the Amazon basin (FREITAS, 2002a; GARCEZ and FREITAS, 2008; SIQUEIRA-SOUZA *et al*., 2016) representing 95% of the fish landed in the region (BATISTA, 1998; RIBEIRO *et al*., 1999; FREITAS *et al*., 2007; CARDOSO and FREITAS, 2012).

But, the rising in the fisheries on this order, already is supporting the fish stock overfishing (BATISTA *et al*., 2004; PETRERE JR. *et al*., 2004) and the declining in natural fish stock at the Amazon basin is growing each year (GARCEZ and FREITAS, 2011; CAMPOS *et al*., 2015), achieving a estimative about 47% of the available fish stocks, also 18% became overfished and 10% depleted (AGOSTINHO *et al*., 2007). But, the absence of continued studies on fisheries in the Amazon basin, make difficult to obtain a precise results from fisheries production in this region (OLIVEIRA JÚNIOR *et al*., 2016). The decrease of fisheries production and effort during the rinsing and flood periods in the study area is probably supported by the incidence of fisheries closed season, regulated by the "defeso subsidy" created by federal law n.° 10.779/2003, which prohibits fishing for the listed species, that occurs in the fisheries landed in this region in the months of November-March (GANDRA, 2010; CORRÊA *et al*., 2014).

The great vulnerability in the capture of migratory fish species occurs due to the formation of large schools in spawning season, facilitating the work of fishermen (GANDRA, 2010). Also, FREITAS and RIVAS (2006) state that the peaks of landings of these species in Manaus, occur in two instances: in the rising and flood periods, coinciding with the migration of some species from the Characiformes Order as (jaraquis *Semaprochilodus* spp., matrinxãs *Brycon* spp., *Myleus* spp. pacus, *Methyni* spp., *Mylossoma* spp. and curimatãs *Prochilodus nigricans*) and the second moment occurs in the period of ebb. The fall of production and effort in the flood and filled in the study area is probably is corroborant with the incidence of closure period (defeso law), which protects the main species landed in the months of November-March (GANDRA, 2010).

The fish species listed in the present research were organized from high to low frequencies classification, related to its occurrence during the landing in the Panairzinha harbor, and become prominence the preference for fish species as tambaqui, tucunaré and curimatã.

Also these fish species high frequency observed in the present study were also reported by BATISTA *et al*. (2007) and by ALMEIDA *et al*. (2007) as the main fish landed from fisheries occurred in the Solimões-Amazonas River, close to the study area. Furthermore, GONÇALVES and BATISTA (2008) when monitoring fisheries in this region, reported a presence of curimatã fish as the most landed fish, followed by the jaraqui, cubiu and tambaqui.

This intensification of fishing on the resource (mainly on the tagged fish species) suggest new strategies to gain in a long period the resource sustainability, for that is necessary design a management instruments in order to organize the natural resource use, focusing on the preservation of fish stock to guarantee its common division between users (AGOSTINHO and GOMES, 2005) also maintaining the ecological sustainability of the first group and the economically gain for the second, once nowadays the Amazonian riverine fishermen has a budget around a minimum salary (GARCEZ *et al*., 2009). In conclusion is necessary to consider a basic aspect, inserting the communities participation in the decision make process, attending to clear and tangible methodologies, to edging on real and correct fisheries resource management plans as well as its environment.

CONCLUSION

The fishing fleet of the Lago Grande in Manacapuru consists of vessels operating in small scale fisheries, producing a fishing average of 274.15 ton.year^{-1}. The predominant fish species in these fisheries were tambaqui, tucunaré and curimatã, representing 45.5% of this production. The frequency of vessels and their production are governed by the Solimões River flood pulse (rising, flood, receding and, drought). In this sense, future decisions involving the fisheries resources of the region, should take actions to ensure the sustainability of local fisheries, considering as vital, the environmental and socioeconomic aspects crucial for the local users groups.

ACKNOWLEDGEMENTS

We are really grateful to the riverine people as well as fishers whose landing at the Panairzinha fishing harbor for their precious cooperation in gathering data. We would also like to acknowledge the PIATAM project (Intelligence Social-Environmental Strategic of Petroleum in the Amazon) and FINEP/PETROBRAS for funding and logistical support for this study.

REFERENCES

AGOSTINHO, A.A.; GOMES, L.C. 2005 O manejo da pesca em reservatório da bacia do alto rio Paraná: avaliação e perspectivas. In: NOGUEIRA, M.G.; HENRY, R.; JORCIN, A., *Ecologia de reservatórios: impactos potenciais, ações de manejo e sistemas em cascata*. Rima, São Carlo, p. 23-56.

AGOSTINHO, A.A.; GOMES, L.C.; PELICICE, F.M. 2007 *Ecologia e Manejo de Recursos Pesqueiros em Reservatórios do Brasil*. Eduem, Maringá, 501p.

ALMEIDA, O.T.; AMARAL, L.; SOUSA JR, W.C.; ALMEIDA, B. 2007 Caracterização da Indústria Pesqueira na Amazônia. In: PETRERE JR. M., *O setor pesqueiro na Amazônia: situação atual e tendências do desenvolvimento a indústria da pesca*. Coleção Estudos Estratégicos, IBAMA - ProVárzea, Manaus, p. 59-75.

BARTHEM, R.B. 1999 A pesca comercial no médio Solimões e sua interação com a reserva de Desenvolvimento Sustentável Mamirauá. In: QUEIROZ, H.L. and CRAMPTOM, W.G.R., *Estratégias para manejo de recursos pesqueiros em Mamirauá*. Sociedade Civil Mamirauá, Brasília-DF, p. 72-107.

BARTHEM, R.B.; PETRERE, M.; ISAAC, V.; RIBEIRO, M.C.L.B.; MCGRATH, D.G.; VIEIRA, I.J.A.; BARCO, M.V. 1997 A pesca na Amazônia: Problemas e perspectivas para o seu manejo. In: VALLADARES-PADUA, C.; BODMER, R.E.; CULLEN, L., *Manejo e conservação de vida silvestre no Brasil*. Sociedade Civil Mamirauá, Belém, p. 173-185.

BATISTA, G.S.; FREITAS, C.E.C; SOARES, M.G.M. 2010 Descrição da pesca com redinha e escolhedeira na área do Ayapuá, RDS Piagaçú-Purus, rio Purus, Amazonas. *Revista Brasileira de Engenharia de Pesca, 5*(3): 23-35.

BATISTA, V.S. 1998 *Distribuição, dinâmica da frota e dos recursos pesqueiros da Amazônia Central*. Manaus: INPA-FUA, 291p. Tese (Doutorado em Biologia de Água Doce e Pesca Interior) Instituto Nacional de Pesquisas da Amazônia/Fundação Universidade do Amazonas, Manaus.

BATISTA, V.S. 2003 Caracterização da Frota pesqueira de Parintins, Itacoatiara e Manacapuru, Estado do Amazonas. *Acta Amazônica*, 33(2): 1-12.

BATISTA, V.S.; PETRERE JR, M. 2007 Spatial and temporal distribution of fishing resources exploited by the Manaus fishing fleet, Amazonas, Brazil. *Brazilian Journal of Biology*, 67(4): 631-637.

BATISTA, V.S.; CHAVES, M.P.S.R.; FARIA JR., C.H.; OLIVEIRA, M.F.G.; INHAMUNS, A.J.S.; BANDEIRA, C.F. 2007 Caracterização Socioeconômica da Atividade Pesqueira e da Estrutura de Comercialização do Pescado na Calha Solimões-Amazonas. In: PETRERE JR. M., *O setor pesqueiro na Amazônia: situação atual e tendências do desenvolvimento a indústria da pesca*. IBAMA - ProVárzea, Manaus, p. 19-57.

BATISTA, V.S.; ISAAC, V.J.; VIANA, J.P. 2004 Exploração e manejo dos recursos pesqueiros da Amazônia. In: RUFFINO, M.L., *A pesca e os recursos pesqueiros da Amazônia brasileira*, IBAMA - Provárzea, Manaus, p. 63-151.

BAYLEY, P.B.; PETRERE JR., M. 1989 Amazon fisheries: assessment methods, current status and management options. Canadian Special Publications, *Fisheries and Aquatic Sciences*, 106: 385-398.

BITTENCOURT, M.M.; AMADIO, S.A. 2007 Proposta para identificação rápida dos períodos hidrológicos em áreas de várzea do rio Solimões-Amazonas nas proximidades de Manaus. *Acta Amazônica*, *37*(2): 303-308.

CAMPOS, C.P.; GARCEZ, R.C.S.; CATARINO, M.F.; COSTA, G.A.; FREITAS, C.E.C. 2015 Population dynamics and stock assessment of *Colossoma macropomum* caught in the Manacapuru Lake system (Amazon Basin, Brazil). *Fisheries Management and Ecology*, *22*(5): 400-406.

CAMPOS, J.R.; FERREIRA, L.V.; APEL, M.; PEREIRA, S.M.L. 2007 *Diagnóstico regional: os pescadores e a pesca na região oeste do Pará e Baixo Amazonas*. Mopebam, IBAMA-ProVárzea, Santarém, 78p.

CARDOSO, R. S.; BATISTA, V.S.; JÚNIOR, C. H. F.; MARTINS, W.R. 2004 Aspectos econômicos e operacionais das viagens da frota pesqueira de Manaus, Amazônia Central. *Acta Amazonica*, *34*(2): 301-307.

CARDOSO, R.S. 2005. *A pesca comercial no município de Manicoré (rio Madeira), Amazonas, Brasil*. Manaus: INPA-FUA, 126p. Dissertação (Mestrado em Biologia de Água Doce e Pesca Interior) Instituto Nacional de Pesquisas da Amazônia/ Fundação Universidade do Amazonas, Manaus. Disponível em: http://bdtd.inpa.gov.br/bitstream/tede/1466/1/Dissertacao_Renato_Cardoso.pdf. Acesso em 24 jul. 2016.

CARDOSO, R.S.; FREITAS, C.E.C. 2007 Desembarque e esforço de pesca da frota pesqueira comercial de Manicoré (Médio Rio Madeira), Amazonas, Brasil. *Acta Amazônica, 37*(4): 605-612.

CARDOSO, R.S.; FREITAS, C.E.C. 2012 The commercial fishing fleet using the middle stretch of the Madeira river, Brazil. *Acta Scientiarum Biological Sciences*, *34*(3): 247-253.

CONAGIN, A., BARBIN, D.; DEMÉTRIO, C.G.B. 2008 Modifications for the Tukey test procedure and evaluation of the power and efficiency of multiple comparison procedures. *Scientia Agricola*, *65*(4): 428-432.

CORRÊA, M.A.A.; KAHN, J.R.; FREITAS, C.E.C. 2014 Perverse incentives in fishery management: The case of the defeso in the Brazilian Amazon. *Ecological Economics, 106*(1): 186-194.

FABRÉ, N.N.; ALONSO, J.A. 1998 Recursos Ícticos no Alto Amazonas: sua importância para as Comunidades Ribeirinhas. *Boletim do Museu Paraense Emilio Goeldi*, Série Zoologia, *14*(11): 19-55.

FABRÉ, N.N.; BATISTA, V.S.; WAICHMAN, A.V.; RIBEIRO, M.O.A.S.; PRANG, G. 2007 *Sociobiodiversidade e Conservação da Várzea Amazônica*. Editora Aran, Manaus, 237p.

FALABELLA, P.G.R. 1985 *A pesca no Amazonas: problemas e soluções*. Imprensa Oficial do Estado, Manaus, 189p.

FALABELLA, P.G.R. 1994. *A pesca no Amazonas: problemas e soluções.* Imprensa Oficial do Estado, Manaus, 180p.

FERNANDES, C.C. 1997. Lateral migration of fishes in Amazon floodplains. *Ecology of Freshwater Fish*, *6*(1): 36-44.

FERNANDES V.L.A.; VICENTINI R.F.; BATISTA, V.S. 2009 Caracterização do uso de malhadeiras pela frota pesqueira que desembarca em Manaus e Manacapuru, Amazonas. *Acta Amazonica*, *39*(2): 405-414.

FRAXE, T.J.P. 2004 *Cultura cabocla-ribeirinha: mitos, lendas e transculturalidade*. Annablume, São Paulo, 374p.

FERREIRA, E.J.G.; ZUANON, J.; SANTOS, M.G. 1998 *Peixes comerciais do médio Amazonas – Região de Santarém, PA*. Imprensa Oficial, Brasília. 211p.

FREITAS, C.E.C. 2002a Strategies of the small-scale fisheries on the Central Amazon Foodplain. *Acta Amazônica*, *32*(1): 101-108.

FREITAS, C.E.C. 2002b Recursos pesqueiros Amazônicos: status atual da exploração e perspectivas de desenvolvimento do extrativismo e da piscicultura. In: MELLO, A.F., O *futuro da Amazônia. Dilemas, oportunidades e desafios no limiar do século XXI*. EDUFPA, Belém, p. 101-129.

FREITAS, C.E.C.; GARCEZ, R.C.S. 2004 Fish communities of natural canals between floodplain lakes and Solimões-Amazonas River (Amazon-Brazil). *Acta Limnológica Brasiliensia*, *16*(3): 273-280.

FREITAS, C.E.C.; RIVAS, A.A.F. 2006 A pesca e os recursos pesqueiros na Amazônia Ocidental. *Ciência e Cultura*, *58*(3): 30-32.

FREITAS, C.E.C.; NASCIMENTO, F.A.; SIQUEIRA-SOUZA, F.K. 2007 Levantamento do Estado de Explotação dos Estoques de Curimatã, Jaraqui, Surubim e Tambaqui. In: PETRERE JR. M., *O setor pesqueiro na Amazônia: situação atual e tendências do desenvolvimento a indústria da pesca.* Coleção Estudos Estratégicos, IBAMA-ProVárzea, Manaus, p. 76-100.

FURTADO, L. 1993 *Pescadores do rio Amazonas – um estudo antropológico da pesca ribeirinha numa área amazônica*. Coleção Eduardo Galvão, Belém, 486p.

GANDRA, A.L. 2010 *O mercado de pescado da região metropolitana de Manaus. Série; O mercado de pescado nas grandes cidades Latino-Americanas*. Montevidéu, Infopesca, 91p.

GARCEZ, D.S.; BOTERO, J.I.S.; FABRÉ, N.N. 2009 Caracterização das pescarias de subsistência e comercial praticadas por ribeirinhos de áreas de várzea em Manacapuru, baixo Solimões, Amazonas, Brasil. *Boletim Técnico Científico do Cepnor*, *9*(1): 43-65.

GARCEZ, R.C.S.; FREITAS, C.E.C. 2008 The influence of flood pulse on fish communities of floodplain canals in the Middle Solimões River, Brazil. *Neotropical Ichthyology*, *6*(2): 249-255.

GARCEZ, R.C.S.; FREITAS, C.E.C. 2011 Seasonal catch distribution of tambaqui (*Colossoma macropomum*), Characidae in a central Amazon floodplain lake: implications for sustainable fisheries management. *Journal of Applied Ichthyology*, *27*(1): 118-121.

GAWORA, D. 2003 *Urucu: Impactos sociais, ecológicos e econômicos do projeto de petróleo e gás "Urucu" no estado do Amazonas*. Editora Valer, Manaus, 444p.

GONÇALVES, C.; BATISTA, V. S. 2008 Avaliação do desembarque pesqueiro efetuado em Manacapuru, Amazonas, Brasil. *Acta Amazônica*, *38*(1): 135-144.

GOTELLI, N.J.; ELLISON, A.M. 2011 *Princípios de Estatística em Ecologia*. Artmed, Porto Alegre, 528p.

HURD, L.E.; SOUSA. R.G.C.; SIQUEIRA-SOUZA, F.K.; COOPER, G.J.; KAHN, J.R.; FREITAS, C.E. C. 2016 Amazon floodplain fish communities: Habitat connectivity and conservation in a rapidly deteriorating environment. *Biological Conservation*, *195*(1): 118-127.

IBGE - Instituto Brasileiro de Geografia e Estatística. 2016 Estimativas da população residente nos municípios brasileiros com data de referência em 1º de julho de 2015.

ISAAC, V.J.; ALMEIDA, M.C.; GIARRIZZO, T.; DEUS, C.P.; VALE, R.; KLEIN, G.; BEGOSSI, A. 2015 Food consumption as indicator of the conservation of natural resources in riparian communities of the Brazilian Amazon. *Anais da Academia Brasileira de Ciências*, *87*(1): 1-14.

JUNK, W.J. 1997 General aspects of floodplain ecology with special reference to Amazonian floodplains. In: JUNK, W.J., *The Central Amazon Floodplain: ecology of a pulsing system*. Springer, Verlag, p. 3-20.

JUNK, W.J.; HOWARD-WILLIAMS, C. 1984 Ecology of aquatic macrophytes in Amazonia. In: SIOLI, H., *The Amazon, Limnology and landscape ecology of a naughty tropical river and its basin*. Dr. W. JUNK, Dordrecht, p. 269-293.

JUNK, W.J.; BAYLEY, P.B.; SPARKS, R.E. 1989 The flood concept in river-floodplain systems. In: Dodge, D.P. (Ed.) *Proceedings of the International Large River Symposium*. Canadian special publication of fisheries and aquatic sciences, p. 110-127.

LAKATOS, E.M.; MARCONI, M.A. 1991 *Fundamentos de Metodologia Cientifica*. Atlas, São Paulo, 270p.

LOWE-MCCONNELL, R.H. 1987 *Ecological studies in tropical fish communities*. Cambridge University Press, Cambridge (UK), 382p.

MERONA, B. and GASCUEL, D. 1993 The effects of flood regime and fishing effort on the overall abundance of an exploited fish community in the Amazon floodplain. *Aquatic Living Resource*, *6*(1): 97-108.

MERONA, B.; BITTENCOURT, M.M. 1988 A pesca na Amazônia através do desembarque no mercado de Manaus: Resultados preliminares. *Memoria Sociedad Ciências Naturales La Salle*, *48*(2): 433-455.

MÓRAN, E.F. 1990 *A ecologia humana das populações da Amazônia*. Vozes, Petrópolis, 367p.

OLIVEIRA JÚNIOR, J.G.C.; SILVA, L.P.S.; MALHADO, A.C.M.; BATISTA, V.S.; FABRÉ, N.N.; LADLE, R.J. 2016 Artisanal Fisheries Research: A Need for Globalization? *PLOS ONE*, *11*(3): 1-10.

PARENTE, V.M. 1996 *A economia da pesca em Manaus. Organização da produção e da comercialização.* Rio de Janeiro: UFRJ, 178p. Dissertação (Mestrado em Ciências Sociais em Desenvolvimento, Agricultura e Sociedade) Universidade Federal Rural do Rio de Janeiro, Rio de Janeiro.

PRANCE, G.T. 1980 A terminologia dos tipos de florestas amazônicas sujeitas a inundação. *Acta Amazonica, 10*(3): 495-504.

PETRERE JR, M. 1985 A Pesca Comercial no Rio Solimões-Amazonas e seus Afluentes: Análise dos Informes do Pescado Desembarcado no Mercado Municipal de Manaus (1976-1978). *Ciência e Cultura*, *37*(12): 1987-1999.

PETRERE Jr, M.; BARTHEM, R.B.; CÓRDOBA, E.A. ; GÓMEZ, B.C. 2004 Review of the large catfish fisheries in the upper Amazon and the stock depletion of piraíba (*Brachyplatystoma filamentosum* Lichtenstein). *Reviews in Fish Biology and Fisheries*, *14*(4): 403-414.

RIBEIRO, M.; FABRÉ, N.N. 2003 *Sistemas abertos sustentáveis - SAS. Uma alternativa de gestão ambiental na Amazônia.* Edua, Manaus, 243p.

RIBEIRO, W.; FALCÃO, W.O.; OLIVEIRA, W. 1999 *Perfil econômico do setor pesqueiro do Amazonas.* Fepesca, Manaus, 40p.

RUFFINO, M. L.; ISAAC, V. J. 1994 The fisheries of the lower Amazon: questions of management and development. *Acta Biologica Venezuelica*, *15*(2): 37-46.

RUFFINO, M.L. 2004 *A pesca e os recursos pesqueiros na Amazônia brasileira*. IBAMA - ProVárzea, Manaus, 80p.

RUFFINO, M.L.; SILVA, E.C.S.; SILVA, C.O.; BARTHEM, R.B.; BATISTA, V.S.; GUILLERMO, E.; PINTO, W. 2006 *Estatística Pesqueira do Amazonas e Pará - 2003*. IBAMA - ProVárzea, Manaus, 272p.

SANTOS, A.L.; CUNHA, F.C.; SOARES, M.G.M.; SOUZA, L.P.; FLORENTINO, A.C. 2016 Conhecimento dos pescadores artesanais sobre a composição da dieta dos pacus (Characiformes: Serrasalmidae) na Floresta Nacional do Amapá, rio Araguari, Amapá, Brasil. *Biotemas*, *29*(2): 101-111.

SANTOS, G.M.; SANTOS, A.C.M. 2005 Sustentabilidade da pesca na Amazônia. *Estudos Avançados*, *19*(54): 165-182.

SANTOS, G.M.; FERREIRA, E.G. 1999 Peixes da Bacia Amazônica. In: LOWE-MCCONNEL, R.H., *Estudos ecológicos de comunidades de peixes Tropicais*. EDUSP, São Paulo, p. 345-373.

SIQUEIRA-SOUZA, F.K.; FREITAS, C.E.C.; HURD, L.E.; PETRERE JR. M. 2016 Amazon floodplain fish diversity at different scales: do time and place really matter? *Hydrobiologia*, *776*(1): 99-110.

SOARES, M.G.M.; FREITAS, C.E.C.; OLIVEIRA, A.C.B. 2014 Assembleias de peixes associadas aos bancos de macrófitas aquáticas em lagos manejados da Amazônia Central, Amazonas, Brasil. *Acta Amazônica*, *44*(1): 143-152.

SOUZA, L.A.; FREITAS, C.E.C.; GARCEZ, R.C.S. 2015 Relação entre guildas de peixes, ambientes e petrechos de pesca Baseado no conhecimento tradicional de pescadores da Amazônia Central. *Boletim Instituto da Pesca*, *41*(3): 633-644.