SMALL-SCALE FISHERIES IN THE AMAZON BASIN: GENERAL PATTERNS AND DIVERSITY OF FISH LANDINGS IN FIVE SUB-BASINS

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ABSTRACT

The commercial fisheries existent in the sub-basins of the Madeira, Purus, Juruá, high Solimões and low Amazonas rivers was studied, aiming to build an integrated scenario of fishing at the Amazon Basin. The data were collected in 2012 at the main docks in the cities of Humaitá, Boca do Acre, Juruá, Tabatinga and Parintins. The common name of the fish species was registered, along with other information such as catch (kg), fishing gear, origin and fishing effort. In general, migratory Characiformes were the most abundant. Boca do Acre on the Purus River showed a dominance of Siluriformes, mainly surubim (*Pseudoplatystoma* spp.). In general, fishlandings were higher during the falling water season. Gillnets and a kind of purse seine (locally called "redinha") concentrated the captures and River and lakes were the most explored fishing grounds. The CPUE (catch per unit effort) varied between 12 and 216.5 kg fisher.day^{-1}, with high averages in the Parintins and Juruá Rivers.

Key words: inland commercial fisheries; catch composition; fishing effort; geographical distribution; Amazon

A PESCA DE PEQUENA ESCALA NA BACIA AMAZÔNICA: PADRÕES GERAIS E DIVERSIDADE DOS DESEMBARQUES DE CINCO SUB-BACIAS

RESUMO

A pesca comercial das sub-bacias dos rios Madeira, Purus, Juruá, Alto Solimões e Baixo-Amazonas foi estudada com o objetivo de traçar o perfil integrado da atividade pesqueira na Bacia Amazônica. Os dados foram coletados em 2012, nos principais portos de desembarque das cidades de Humaitá, Boca do Acre, Juruá, Tabatinga e Parintins. O nome comum das espécies foi registrado, assim como a captura (kg), os apetrechos, os pesqueiros e esforço de pesca. Em geral, o desembarque foi dominado por Characiformes migradores. Em Boca do Acre, no rio Purus, os Siluriformes foram mais importantes, com destaque ao surubim, (*Pseudoplatystom*a spp.). Os desembarques foram maiores nos períodos de vazante. Redes de emalhar e um tipo de rede de cerco (chamado localmente de "redinha") concentraram as capturas. Rio e Lagos foram os pesqueiros mais explorados. A CPUE variou de 12 a 216,5 kg homem.dia^{-1}, com maiores valores médios nos municípios de Parintins e Juruá.

Palavras-chave: pesca interior; composição da captura; esforço de pesca; distribuição geográfica da pesca; Amazonas

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INTRODUCTION

In Amazonia, fishing is one of the extractive activities that involves large amounts of people, generating around 200,000 direct jobs and total estimated annual revenue of USD 200 million (FISCHER *et al*., 1992). It supplies regional urban centers with fish (GONÇALVES and BATISTA, 2008; RUFFINO, 2014), the most important source of animal protein for people in the region, particularly rural inhabitants living on the banks of rivers and lakes (SHRIMPTON and GIULIANO, 1979; CERDEIRA *et al*., 1997; ISAAC and ALMEIDA, 2011).

The Amazon Basin is a huge network of aquatic environments, with water chemistry of the rivers, lakes and streams determined by the soils found in each particular watershed (JUNK *et al*., 1989). The most abundant fish populations are found in white water flood plains, such as the Solimões-Amazonas River, whose headwaters originate in the Peruvian Andes. (IRION *et al*., 1997). Although the Solimões-Amazonas floodplain is relatively homogeneous between Tabatinga in the upper Solimões and Parintins in the middle reach of the Amazonas River, the fishing catch of commercial species could exhibit marked differences dictated by market preferences and fisher behavior. The large seasonal fluctuation in water level (> 10 meters) offers dynamic variability in aquatic habitats and fishing grounds. Amazonian fishers' in-depth knowledge of the behavior of commercial species is demonstrated by their use of a wide arsenal of artisanal fishing gear, which varies based on changes in the hydrological cycle and the type of fishing ground being exploited (FREITAS *et al*., 2002; BATISTA and PETRERE, 2007).

Commercial fishing takes place along river banks and channels, on beaches and ressacas, as well as in flooded areas, such as lakes, furos and paranás. It is carried out in large and medium-sized boats that can travel over 500 km, as well as small wooden canoes better for travelling shorter distances and managing the nets (PETRERE, 1978b; BATISTA *et al*., 2012; CARDOSO and FREITAS, 2012; INOMATA and FREITAS, 2015). Approximately 200 species of fish are procured for food consumption along the Solimões-Amazonas River (BARTHEM, 1995; BARTHEM and FABRÉ, 2004), where catch composition varies widely according to the specific region (BATISTA *et al*., 2012). This variation is linked to several factors, including fluctuations in the hydrological cycle, floodplain extension, number of floodplain lakes, seasonal movements of target species, and overfishing (CASTELLO *et al*., 2013), As well, extrinsic factors such as market preferences and individual knowledge of fishers also influence catch composition. .

Due to population growth in the Amazon over the last four decades and the consequent increase in fishing effort to meet the demand for fish in expanding urban centers, some species have already been overfished, which results in a reduced number of landings and smaller fish being caught (PETRERE, 1983; MÉRONA and BITTENCOURT, 1988; BARTHEM and GOULDING, 1997; RUFFINO and ISAAC, 1999; PETRERE *et al*., 2004; FREITAS *et al*., 2007; CASTELLO *et al*., 2011; CAMPOS and FREITAS, 2014; CATARINO *et al*., 2014; SANT' ANA *et al*., 2014).

The lack of cooperation among different authorities and the discontinuance of fishery-monitoring programs have prevented a more comprehensive synopsis of the fleets' activities. Therefore, it is extremely important to renew regular monitoring efforts, to be able to track fishing activity in large urban centers and also in the interior. Amazonas State is the largest in Brazil, covering more than 1.5 million square meters and encompassing large variability in aquatic systems. Fishing activity in the state is influenced by market demand, which, consequently, is a product of economic, social and cultural factors.

Preliminary and fragmented studies showed that fish landings in urban centers in the central part of the Amazon primarily consist of migratory Characiformes, especially prochilodontids (BITTENCOURT and COX-FERNANDES, 1990; BATISTA and PETRERE, 2003), while Siluriformes are more common in urban centers in the lower reach of the Amazon, in the Amazonas River estuary (BARTHEM and FABRÉ, 2004) and in the upper Solimões (PETRERE *et al*., 2004). Therefore, this study sought to analyze the similarities and differences in commercial fishing in different areas of Amazonas State, based on fish landings in urban centers representing the five largest sub-

basins of the Solimões-Amazonas River. This comparative analysis was based on information about total and per-species catch, fishing grounds, fishing gear used and fishing effort. We hypothesized that there would be differences in catch composition in relation to fishing gear used and catch per unit effort among small scale commercial fisheries along the Solimões-Amazonas River

MATERIAL AND METHODS

Study area

Data on fish landings were collected in the cities of Boca do Acre, Humaitá, Juruá, Tabatinga and Parintins. These are the administrative centers of the principal municipalities of the Purus, Madeira and Juruá rivers and of the central channel of the Solimões/Amazon River, respectively (Figure 1). These sub-basins are typical of whitewater rivers and account for most of the commercial fish production in the state of Amazonas.

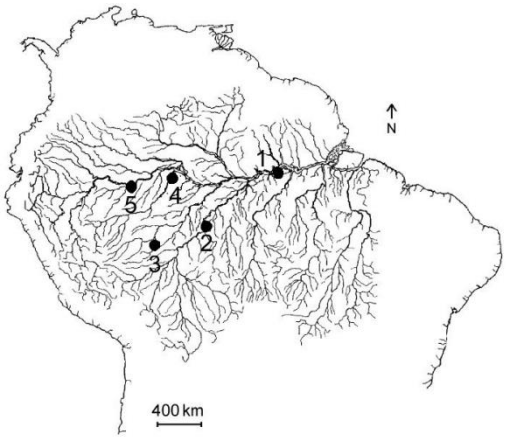

Figure 1. Geographic location of the administrative centers of the municipalities in the Amazon basin. 1 = Parintins, Lower Amazon river; 2 = Humaitá, Madeira river; 3 = Boca do Acre, Purus river; 4 = Juruá, Juruá river; and 5 = Tabatinga, Upper Solimões river.

Data collection

Fish landing data were collected daily with a structured questionnaire between January and December 2012 in the municipalities of Juruá (368 questionnaires applied) and Tabatinga (748 questionnaires). In Boca do Acre (333 questionnaires), Humaitá (382) and Parintins (482), the data for 2012 were completed with records from September to December 2010. The questionnaires were applied in interviews with the person in charge of each boat when fish was being landed. The information recorded covered production (kg) per species, fishing gear used, fishing grounds exploited, number of people who took part and duration of each trip. Some of the forms only contained catch data as respondents did not provide information about the fishing gear used.

Mean monthly water levels, provided by the Brazilian Mineral Resource Research Company (CPRM), were used to describe the hydrological cycles in the sub-basins from the years 2010 to 2012. With the exception of the municipality of Juruá, where this information was not available, we therefore used the data for Tabatinga, the closest municipality to it.

Data analysis

A list of the common names of the fish species recorded and their possible taxonomic identity was drawn up based on the current literature (REIS *et al*., 2003) and by consulting specialists at the Federal University of Amazonas (UFAM) and the National Amazonian Research Institute (INPA). Total fish landings (kg) were calculated for each municipality. They were then broken down by type of fishing ground, fishing gear and month and also compared with the annual hydrological cycle. Catch per unit effort (CPUE) was calculated dividing the catch per fishing trip (kg) by fishing effort expressed as number of fishers multiplied by the number of days spent in the fishing trip) (PETRERE, 1978).

RESULTS

Catch composition

Seventy-six common names of fishes were recorded. This number potentially corresponds to a larger number of species because the same common name can be used to designate different species. The greatest variety of fish in landings was recorded in Humaitá (36) and Juruá (35)

followed by Parintins and Boca do Acre, with 34 types of fish each (common names), and Tabatinga with 22. Slightly over 10% of the species (mainly migratory Characiformes) were found in landings in all the municipalities (Table 1).

Fish landings

In Parintins, Juruá and Humaitá, around 80% of fish landed were Characiformes, in contrast to Boca do Acre, where Siluriformes were the most common (Table 2). In Tabatinga, the most common fishes were salada, a grouping that corresponds to a variety of species of little commercial value. Curimatã (*Prochilodus nigricans*), jaraquis (*Semaprochilodus* spp.), pacu (*Mylossoma* spp.) and (*Metynnis* spp.) and matrinxã (*Brycon amazonicus*) accounted for over half of overall production in the municipalities. They were also the species or species group that accounted for more than 10% of total production in Parintins, Juruá and Humaitá, *Pseudoplatystoma* spp., representing a species group known as pintado, surubim and caparari, was the only catfish (order Siluriformes) to account for over 10% of landings in one of the municipalities. Parintins was the municipality with the largest landings, followed by Boca do Acre, Tabatinga, Juruá and Humaitá (Table 2). Mean monthly landings were 63.0 t ± 7 in Parintins, 12.7 t ± 7 in Boca do Acre, 8.5 t ± 12 in Tabatinga, 7.5 t ± 4 in Juruá and 5.5 t ± 4 in Humaitá. In general, production peaks in the municipalities were associated with the falling-water period with the exception of Parintins, where the largest values were recorded in the flood period. In Boca do Acre, the largest landings were for surubim (*Pseudoplatystoma* spp.), which represented 12.5% of production in May and 13.7% in July. Cuiú-cuiú (*Oxydoras niger*) accounted for 11.8% of landings in May, and mandí (*Pimelodus* spp.) for 15.6% in July (Figure 2). In Humaitá, jaraqui (*Semaprochilodus* spp.) accounted for 86% of the total catch landed in April, while in May jaraqui (*Semaprochilodus* spp.) and jatuarana (*Brycon melanopterus*) were the most important species, accounting for 23.4% and 22.3%, respectively (Figure 3). In Tabatinga, production peaks were in July (99.4%) and October (84%), when a variety of species, commonly referred to as salada, were landed (Figure 4). In Juruá peaks were recorded in March, April and May. In March, jaraqui (*Semaprochilodus* spp.) represented 45.5% of the landings, followed by matrinxã (*Brycon amazonicus*) with 40.3%. In April, matrinxã and curimatã (*Prochilodus nigricans*) were responsible for 30% and 24.5%, respectively, while in May pacús (*Mylossoma* spp.) and (*Metynnis* spp.) were more important, accounting for 49.8% of landings (Figure 5). In Parintins, the species that accounted for the largest proportion of landings in the months of April and May were jaraqui (*Semaprochilodus* spp.) and curimatã (*P. nigricans*) with 46% and 30%, respectively. Another peak was observed in July, when curimatã (*P. nigricans*) (51.2%) and pacu, (*Mylossoma* spp.) and (*Metynnis* spp.) (17.7%) were the most common fishes (Figure 6).

Table 1. Types of fish and total fish landings (in kg) in the municipalities in 2012. BA = Boca do Acre; HU = Humaitá; JU = Juruá; PA = Parintins; TA = Tabatinga.

Species	Common name	BA	HU	JU	PA	TA	Subtotal
Acestrorhynchus spp.	Peixe cachorro	193	4			50	247
Leporinus spp.	Piau; Aracu cabeça gorda	3830	55	4711		111	8707
Leporinus fasciatus	Aracu flamengo			20			20
Schizodon fasciatus	Aracu comum		130	1795	32522		34447
Arapaima gigas	Pirarucu				4471		4471
Ageneiosus spp.	Fidalgo; Mandubé; Bocão	4876			700	30	5606
Ageneiosus spp.	Boca de bolsa				5867		5867
Hoplosternum littorale	Tamoatá		392		1200		1592
Brycon amazonicus	Matrinxã	18209	214	10222	41681	830	71156
Brycon melanopterus	Jatuarana		4317	72			4389
Colossoma macropomum	Tambaqui; Ruelo	971	714	1379	19780	1280	24124
Mylossoma spp.; *Metynnis* spp.; *Myleus* spp.	Pacu	12151	8181	23692	41452	1975	87451
Piaractus brachypomus	Pirapitinga	8335	17	4537	19972	659	33520
Pygocentrus nattereri	Piranha caju			552			552
Serrasalmus spp.	Piranha; Piranha preta	1197	899	301	1891	25	4313

Triportheus spp.	Sardinha	412	2807	1252	3616	190	8277
Astronotus spp.	Acará açu	1493	959	1046	6198		9696
Chaetobranchus spp.	Acará branco		36	58			94
Cichla spp.	Tucunaré, Tucunaré amarelo	6599	1098	4323	11222		23242
Crenicichla spp.	Jacundá			20			20
Geophagus spp.	Acará tinga			140			140
Heros spp.	Acará roxo				29		29
Boulengerella lucius	Peixe agulha		12				12
Potamorhina spp.	Branquinha; Chorão	37	6022	2690	8362	1660	18771
Rhaphiodon vulpinus	Saranha			150			150
Lithodoras dorsalis	Bacu pedra					220	220
Oxydoras niger	Cuiú cuiú; Cujuba	13773	28	860	1091		15752
Pterodoras granulosus	Bacu liso		11		11000	105	11116
Hoplerythrinus unitaeniatus	Jejú			35			35
Hoplias malabaricus	Traíra	221	688	40			949
Anodus spp.*; Hemiodus* spp.	Charuto; Saúna	197			5590		5787
Pterygoplichthys pardalis	Acari bodó	315	898	499	38484	510	40706
Osteoglossum bicirrhosum	Aruanã	143	437	5750	8696		15026
Brachyplatystoma capapretum; B. filamentosum	Filhote; Flecheiro; Piraíba	6970	671		330	630	8601
Brachyplatystoma platynemum; Goslinia platynema	Babão		446				446
Brachyplatystoma rousseauxii	Dourada	256	1105	18	1378		2757
Brachyplatystoma vaillantii	Piramutaba; Piaba	8742	3073	60			11875
Calophysus macropterus	Piracatinga				2000		2000
Hypophthalmus spp.	Mapará	721		15	17750		18486
Leiarius marmoratus	Jandiá	1847		68	1000	10	2925
Leiarius pictus	Jandiá preto	567					567
Phractocephalus hemioliopterus	Pirarara		1892	922	487		3301
Pimelodus blochii; Pimelodina flavipinnis	Mandí	10922					10922
Pinirampus pirinampus	Piranambú; Barbado; Barba chata	1322	93	160	100		1675
Platynematichthys notatus	Cara de gato				1391		1391
Pseudoplatystoma spp.	Pintado; Surubim; Caparari	21935	1319	2736	12865	120	38975
Sorubimichthys planiceps	Peixe lenha; Pirauaca	423	4				427
Zungaro zungaro	Jaú; Pacamom	4726	222	391	30		5369
Pellona castelnaeana	Apapá amarelo; Sardinha amarela; Arenga	2577	38			300	2915
Pellona flavipinnis	Apapá branco; Sardinha branca; Arenga	335	8		477	210	1030
Prochilodus nigricans	Curimatã	6772	6079	8694	251845	479	273869
Semaprochilodus spp.	Jaraqui; Jaraqui escama grossa; Jaraqui escama fina	200	21933	9629	180242	30	212034
Plagioscion squamosissimus	Pescada	1400	602	1741	21186	60	24989
Salada						91321	91321
Others		1729	103	20			1852
Number of species		**34**	**36**	**35**	**34**	**22**	
Total		**144396**	**65507**	**88598**	**754905**	**100805**	**1154211**

Table 2. Total catch (in kg) of Characiformes (CH) and Siluriformes (SI) and their respective percentage of total catch by municipality. Species and common names that accounted for more than 10% of total production are shown separately.

Municipality	Total weight (1,000 kg)	CH (1,000kg)	%	> 10%	SI (1,000kg)	%	> 10%
Parintins	754.9	606.9	80.4	Curimatã (33%) Jaraqui (23%)	95.7	13	
Boca do Acre	144.4	52.7	36.5	Matrinxã (12%)	77.4	54	Surubim (10%)
Tabatinga	100.8	7.8	7.2	Salada (90%)	1.6	2,2	
Juruá	88.6	69.8	78.7	Pacu (26%), Matrinxã (11%)	5.7	8	
Humaitá	65.5	52.1	79.0	Jaraqui (31%), Pacu (12%)	10.1	16	
Total	1,154.2	789.3			190.6		

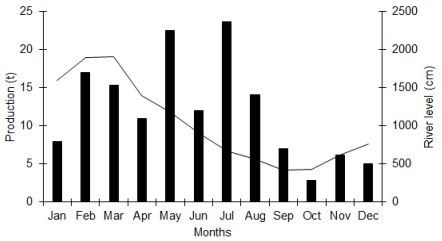

Figure 2. Monthly commercial fish landings in Boca do Acre. Bars denote fish production and lines the river level.

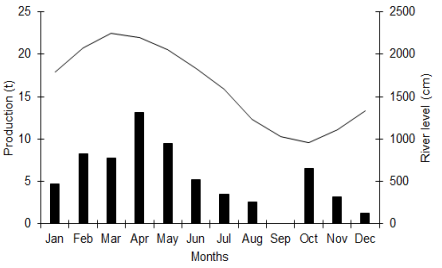

Figure 3. Monthly commercial fish landings in Humaitá. Bars denote fish production and lines the river level. No data was available for September.

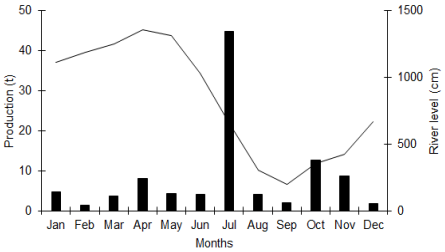

Figure 4. Monthly commercial fish landings in Tabatinga. Bars denote fish production and lines the river level.

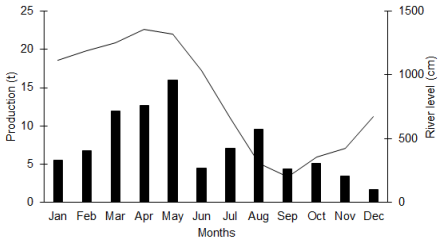

Figure 5. Monthly commercial fish landings in Juruá. Bars denote fish production and lines the river level.

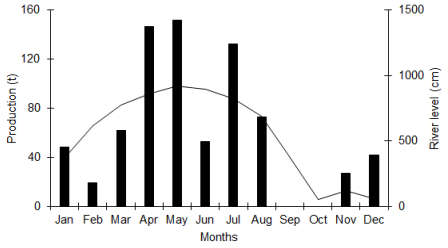

Figure 6. Monthly commercial fish landings in Parintins. Bars denote fish production and lines the river level. No data was available for September and October.

Fishing grounds

The Juruá and Parintins fishing fleets exploited a wider variety of fishing grounds. Beaches and rivers were exploited in all the sub-basins. Lakes were exploited by all the fleets, with the exception for the fleet of Boca do Acre. An island environment was only used by fishers in Parintins, and igapós only by fishers in Juruá (Table 3). The fishing grounds with the greatest production were rivers, lakes and paranás, while those with the lowest production were igapós and islands (Table 3).

Fishing on beach grounds, although exploited by all the fleets, made only a small contribution to fish landings. Igarapés, although found in most of the municipalities, followed a similar pattern. Igapós and islands were even less important and were only exploited in Juruá and Parintins (Table 3).

Fishing gear

Thirteen types of fishing gear were used. Hooks and gillnets were used in all the sub-basins. In Parintins, on the Lower Amazon River, 76% of the different types of fishing gear listed were used. In Boca do Acre, 23% were used on the Purus River, 46% on the Madeira River, 61% on the Juruá River and 38% on the Upper Solimões River. More than 95% of the fish were caught with gillnets or redinhas (61% and 36%, respectively). Hooks accounted for the third largest proportion of fish landings and for a particularly significant proportion in Boca do Acre and Humaitá (Table 4). Bottom longlines and handlines were not included in

the table because they accounted for less than 100 kg year-1 of landings and were each used in only one of the sub-basins (Madeira River and Amazon River, respectively).

Catch per unit effort (CPUE)

CPUE varied from 12 to 216.5 kg man.day-1 throughout the year. Parintins, Juruá and Tabatinga had the highest mean CPUE values, followed by Boca do Acre and Humaitá. In Parantins two peaks in CPUE were recorded: one at the end of the flood period, in April and May, and another at the beginning of the falling-water period, in July. This pattern was similar to that found in Juruá. In Tabatinga the highest value was recorded at the beginning of the flood period, in the month of October. In Boca do Acre, the highest CPUE values were recorded at the end of the flood period, at the beginning of February, and during the falling-water period, between May and August (Table 5). The highest CPUE values were recorded in the falling-water period in Boca do Acre, Juruá and Parintins, and in the flood period in Humaitá and Tabatinga. The start of the flood period was marked by low values of CPUE in Boca do Acre, Humaitá and Juruá, while in Tabatinga and Parintins the lowest figures were observed during the falling-water and dry seasons, respectively.

Table 3. Fish production (kg) for each type of fishing ground exploited by the fleets in each municipality.

Municipality	Igapó	Igarapé	Island	Lake	Paraná	Beach	River	Subtotal
BO		2,070				3,447	139,079	144,596
HU				43,452		3,773	18,282	65,507
JU	300	1,611		34,380	2,851	20	49,436	88,598
PA		450	255	155,559	121,415	400	476,826	754,905
TA				48,040		1,870	50,895	100,805
Total	300	4,131	255	281,431	124,266	9,510	734,518	1,154,411

Table 4. Types of fishing gear used and the amount of fish (in kg) landed with each type of gear in the municipalities studied. HK = hook; BA = bow and arrow; HP = harpoon; DN = dragnet; BO = boinha; RL = rod and line; BL = surface longline; GN = gillnet; RD = redinha; CN = castnet; SP = spear.

Municipality	HK	BA	HP	DN	BO	RL	LL	GN	RD	CN	SP
Boca do Acre	5199							140068		270	
Humaitá	8238			126			190	54513	4542		
Juruá	821	205		58			855	56794	31115	365	505
Parintins	258		884	3382	187	166	381	325767	374896	430	
Tabatinga	264			35			50	112898	260		
Total	14780	205	884	3601	187	166	1476	690040	410813	1065	505

Table 5. Variation in Catch per Unit Effort (CPUE) throughout 2012.

Sub-Basin	J	F	M	A	M	J	J	A	S	O	N	D	$\overline{x \pm s}$
Purus	14.8	23.7	20.8	18.8	23.2	22.4	31.3	33.7	17	14.5	25.4	17.5	22 ± 6
Madeira	12.8	16.8	16	14.8	16.4	13.4	14.3	13.4		15.2	13.5	12.3	14.4 ± 1.5
Juruá	36.2	41	95	88.2	92.3	50.7	46.3	109.2	41.5	37.5	38.4	26	58.5 ± 28.8
Baixo Amazonas	26	36	36.2	31.3	44.3	43.8	216.5	71			94.8	12	61.2 ± 59.4
Alto Solimões	17	74	37.8	41.2	22	28.2	28.7	14.5	16.8	121.8	52.2	53	42.2 ± 30.8

DISCUSSION

Our results show that at least 76 species or species groups were exploited by commercial fishers in the five sub-basins studied. This represents less than half of the number exploited by commercial and subsistence fishers throughout the Amazon Basin, which is estimated to be around 200 species (BARTHEM and FABRÉ, 2004). The number of species landed varied between 22 and 36. This variation appears to be a pattern throughout the basin, particularly along the Solimões/Amazon River channel, where 20 to 72 species have been recorded as being commercially exploited (PROVÁRZEA, 2006; BATISTA *et al*., 2012).

Fish landings in Parintins, Juruá and Humaitá consisted mainly of migratory Characiformes, especially jaraquis (*Semaprochilodus* spp.), matrinxã (*Brycon amazonicus*), pacus (*Mylossoma* spp.), (*Metynnis* spp.) and curimatã (*Prochilodus nigricans*). These species are very abundant in whitewater rivers (BATHEM and GOULDING, 2007), where they form large shoals during spawning migrations (ARAÚJO-LIMA and RUFFINO, 2003; RIBEIRO and PETRERE, 2006). Their population parameters and life strategies are typical of r-strategists (RIBEIRO and PETRERE, 2006; SANTOS-FILHO and BATISTA, 2009; CATARINO *et al*., 2014). Larvae and juveniles of these species use floodplains as nursery grounds, taking advantage of the food supply, which stimulates their fast growth. They generally reach maturity around two years of age, when they form large shoals and leave the floodplain to reproduce in the main channel of whitewater rivers (COX-FERNANDES, 1997). After reproducing, they return to the floodplain, where they feed until the start of the falling-water period, when they once again leave the floodplain in large shoals and migrate upstream in search of new areas where they can stay during the dry season (GOULDING, 1979; RIBEIRO, 1983; COX-FERNANDES, 1997; ARAÚJO-LIMA and RUFFINO, 2003). During these periods of reproductive and dispersive migration, the shoals are intensively exploited by the commercial fishing fleet (BATISTA, 2004).

In Parintins, *Prochilodus nigricans*, *Semaprochilodus insignis* and *Semaprochilodus taenirus* accounted for more than 10% of landings, a similar result to that found in 2003 in the same region (PROVÁRZEA, 2006). In Juruá, *Brycon amazonicus*, *P. nigricans*, *S. insignis*, *S. taenirus* and various species of Myleinae, commonly known as pacu, made up most of the production. In 2009/2010, only pacus (*Mylossoma* spp.) and (*Myleus* spp.) stood out in the landings recorded in this municipality (ALCÂNTARA *et al*., 2015). In Humaitá, jaraqui (*S. insignis*), (*S. taenirus*), pacu (*Mylossoma* spp. and *Metynnis* spp.) were the most-landed species, confirming the results observed in Manicoré, another town on the lower stretch of the Madeira River (CARDOSO and FREITAS, 2008). In Porto Velho, a municipality located upstream of Humaitá, dourada (*Brachyplatystoma rousseauxii*) and filhote, (*Brachyplatystoma filamentosum*) also accounted for a significant proportion of landings in 2004 (DORIA *et al*., 2012).

Fishing in Boca do Acre focused on various species of migratory catfish (Siluriformes), most notably surubim (*Psudoplatystoma* spp.) The importance of this group in landings in the Upper Purus has already been reported by ALMEIDA *et al*. (2012), who found that in addition to surubim (*Pseudoplatystoma tigrinum*), jandiá (*Leiarius marmoratus*), filhote (*Brachyplatystoma filamentosum*) and mandi (*Pimelodus* cf. *altipinnis*) were the most frequently caught species.

The importance of Siluriformes to fishing in the upper stretch of the Purus River corroborates findings in the estuary region of the Lower Amazon and Upper Solimões (BARTHEM and GOULDING, 2007). There are many fish processors in these regions that buy this type of fish, primarily to supply the Peruvian and Colombian markets (BARTHEM and GOULDING, 2007). Because Boca do Acre is close to Rio Branco, the capital of the state of Acre, catfish production in this municipality is probably shipped to Rio Branco.

Although the largest landing was recorded in Parintins, followed by Boca do Acre, Tabatinga, Juruá, and Humaitá, it was less than half that recorded in 2003 (1,730 t)

(PROVÁRZEA, 2006). In Boca do Acre, total catch was similar to the figure for 2008, when 163 t were landed (PROVÁRZEA, 2006). In contrast, the value recorded in Tabatinga was much less than the 3,000 t recorded in 2003 (PROVÁRZEA, 2006). In Juruá, 88 t were landed, slightly more than the 60 t reported by ALCÂNTARA *et al*. (2015). In Humaitá production was 65 t, which was also less than the figure reported by the fisher association in the period 2001 to 2004 (DORIA *et al*. 2012).

The rivers and their floodplains, where the lakes are notable for their yield, were the most productive fishing grounds, although their importance varied from one sub-basin to the next. In Boca do Acre, the river was the main fishing ground used by the fishing fleet. In the other municipalities, lakes and paranás were of equal importance, as already reported by other authors (PETRERE, 1978b; BARTHEM and GOULDING, 2007).

A variety of fishing gear was used, of which more than one was normally used in the same fishing trip, indicating the multispecific nature of fishing in Amazonia (FREITAS *et al*., 2002; BATISTA and PETRERE, 2003). However, most of the fish landed was caught with gillnets and redinhas, corroborating the findings of other authors for the Amazon region (BATISTA and PETRERE, 2003). Gillnets are normally used throughout the year, particularly in lakes and flooded areas. Redinhas, on the other hand, are used primarily to catch species that form large shoals, particularly Characiformes, and are used predominantly in river fishing (PETRERE, 1978b; BARTHEM, 1999).

The unit of fishing effort measured in fisher *per* day is generally chosen to describe Amazonian fisheries because different type of gear are used in a same fishing trip, making it difficult to use more specific units of fishing effort (PETRERE, 1978a). CPUE in all the municipalities varied substantially throughout the year, probably because of changes in the spatial distribution of fishes at different stages of the hydrological cycle (BARTHEM, 1999; CARDOSO and FREITAS, 2007). In Parintins, mean CPUE was 61.2 kg fisher.day^{-1}, significantly greater than the previous reference figure for the fleet in that municipality (10.6 kg fisher.day^{-1}) (PROVÁRZEA, 2006), and very close to that reported for Tefé (63.6 kg fisher.day^{-1}) (VIANA, 2004). In Juruá, mean CPUE was 58.5 kg fisher.day^{-1}, slightly less than the 68.5 kg fisher.day^{-1} recorded by ALCÂNTARA *et al*. (2015), one of the largest figures for Amazonia. Although smaller than the estimated figures for Parintins and Juruá, the CPUE for Tabatinga was also high (42.2 kg fisher.day^{-1}) and was greater than that recorded in 2003 (32.5 kg fisher.day^{-1}) (PROVÁRZEA, 2006). Humaitá and Boca do Acre had the smallest mean CPUE, which may be related to ecological factors not investigated in this study.

CONCLUSION

The socio-economic importance of freshwater fishing in developing countries is frequently underestimated. The large variation observed in catch composition, especially in the catch accounted for each species, also in total fish production and types of fishing ground and fishing gear used, indicates that fisheries in the Amazon are very diverse. Altogether, various factors, such as the intensity and duration of the different hydrological periods, fishing effort, market preferences and the diversity and size of the different habitats influences the diversity of Amazonian fisheries.

This variability needs to be taken into account when developing effective management strategies, in this way it is recommended that management agencies should avoid generalist management policies that could prove ineffective or even adversely affect stock sustainability and fishing itself are avoided.

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