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DYNAMICS OF COMMERCIAL FISHERY AT THE MIDDLE STRETCH OF THE NEGRO RIVER: EXPLOITATION INTENSITY BY FISHING GROUNDS

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ABSTRACT

In the middle Negro River, there have been several conflicts between the different fishing modalities due to the differential use of the fishing resource and the dispute over the same fishing areas. In this way, the spatial dynamics of commercial fishing in the municipality of Barcelos in the middle Negro River were analyzed, aiming to identify the locations used in the fisheries that may have different potentials and demand different actions. Information was collected from commercial fisher regarding the location of fishing sites and the frequency of use during high and low water periods. The geographic coordinates were identified with Q-Gis software and later submitted to a kernel-intensity technique. Eight fishing sites were used in commercial fisheries in Barcelos. In both hydrological periods, fishing occurred with a greater intensity in the Demeni River. Its waters change from light to white throughout the year, and there are several marginal areas that could serve as nurseries for various species of fish. Possibly, in this environment, there is a greater probability of conflicts occurring between the different resource users since this river is also exploited by recreational and subsistence fishers. This result shows that the spatial dynamics of fisheries can be truly important for management proposals.

Key words: inland fishery; fishing zoning; kernel; Barcelos.

DINÂMICA ESPACIAL DA PESCA COMERCIAL NO MÉDIO RIO NEGRO: INTENSIDADE DE EXPLOTAÇÃO POR ÁREAS DE PESCA

RESUMO

No Médio rio Negro vem ocorrendo diversos conflitos entre as diferentes modalidades de pesca devido ao uso diferencial do recurso pesqueiro e à disputa pelas mesmas áreas de pesca. Dessa forma, foi analisada a dinâmica espacial da pesca comercial no município de Barcelos, no Médio rio Negro, visando espacializar os locais utilizados nas pescarias que podem possuir diferentes potencialidades e demandar ações distintas. Foram coletadas informações com os pescadores comerciais, referentes à localização dos locais de pesca e frequência de uso durante os períodos de águas altas e baixas. As coordenadas geográficas foram espacializadas com o auxílio do software Q-Gis e posteriormente foram submetidas a técnica de intensidade de Kernel. Foram utilizados oito locais de pesca nas pescarias comerciais em Barcelos. Nos dois períodos hidrológicos as pescarias ocorreram com maior intensidade no rio Demeni. Suas águas mudam de claras para brancas ao longo do ano e existem várias áreas marginais que poderiam servir de berçário para várias espécies de peixes. Possivelmente, nesse ambiente existe a maior probabilidade de ocorrerem conflitos entre os diferentes usuários dos recursos, visto que esse rio também é explorado pelos pescadores recreativos e de subsistência. Este resultado mostra que a dinâmica espacial das pescarias pode ser realmente importante para as propostas de manejo.

Palavras-chave: pesca interior; zoneamento pesqueiro; kernel; Barcelos.

INTRODUCTION

The Amazon basin hosts one of the most important freshwater fisheries in the world, which is characterized by a high diversity of exploited species and a large number of people engaged in fishing, including riverine people (Freitas et al., 2002; Ruffino, 2005). It has been estimated that fishing is the main income source for approximately 200,000 people (Fischer et al., 1992) and that more than 200 fish species have been

exploited (Barthem and Fabré, 2004), resulting in a total catch of approximately 150,000 tons per year in Amazonas State alone (Gandra, 2010).

In the middle Negro River, there are four types of fisheries: ornamental, recreational, subsistence and commercial, and they substantially contribute to the regional economy and the welfare of people (Freitas and Rivas, 2006; Correia, 2014). The ornamental fishery is performed to the capture of demanded by the aquarium market; fishers use dip nets and traps as fishing gears. The recreational fishery is predominantly developed in black water rivers toward several species of *Cichla*. Riverine people practice the subsistence fishery and the production is destined for your own alimentation. And professional fishers practice the commercial fishing and the capture is destined for the commercialization in the main urban centers of the region (Santos and Santos, 2005; Freitas and Rivas, 2006).

The white water rivers are more productive in terms of animal biomass than black water rivers, possibly due to the productivity of the adjacent floodplains that are annually flooded by rich sediments water (Saint-Paul and Bayley, 1979; Junk and Piedade, 1993; Isaac et al., 2016). However, the commercial fishing in the middle Negro River has social and economic importance, and the production is landed in the markets of local urban centers, mainly Barcelos, Santa Isabel do Rio Negro and São Gabriel da Cachoeira, and some boats move toward Manaus to sell their production (Silva, 2003; Correia, 2014).

Due to its low importance in the regional context, studies on Negro River commercial fisheries are scarce (Silva, 2003; Correia, 2014; Inomata and Freitas, 2015), and none have addressed the spatial distribution of commercial fishing, describing the fishing grounds and their exploitation intensity. This is essential information as a baseline for fishery management, mainly in freshwater and small-scale fisheries, where a fisher's knowledge is very important to the success of the fishery (Begossi, 2004). Furthermore, in the Negro River basin, with the development of recreational fishery emerged new conflicts between different types of fishers that are associated with the use of fishing resources and the territoriality (Freitas and Rivas, 2006; Barra et al., 2010; Correia, 2014). And, knowledge on the spatial distribution of the fishery could be very useful to fishery management proposals, including fishing zoning.

Geographic information system (GIS) tools have been extensively used to study fishing fleet distributions (Caddy and Carocci, 1999). Begossi (2001) showed the utility of GIS tools as the basis for the management of small-scale fisheries in southeastern Brazil. Sousa and Freitas (2011) used GIS to perform a spatial analysis of the commercial fishery of *Colossoma macropomum* on the lower stretch of the Solimões river. This study aimed to investigate the spatial distribution of commercial fishing performed in the Middle Negro river basin by joining the GIS approach and fishers' knowledge to contribute to future proposals for the sustainable management of this fishery.

MATERIAL AND METHODS

Study area

The municipality of Barcelos, located on the left bank of the middle Negro River, was the focal area (Figure 1). It is the main urban center in this region and concentrates fish landings and harbors the more important fishing fleet (Inomata and Freitas, 2015). The Negro River is a typical black water river with a low concentration of nutrients and a small primary productivity (Goulding et al., 1988).

Data collection

The analyzed data comes from the project database "Zoning of fisheries to promote sustainable development and minimize conflicts between fisheries in Barcelos, AM" of FAPEAM/PROPESCA/RIONEGRO which started in 2015. The information extracted was related to the fishing area and frequency of fishing in each site for the extreme stations of the hydrological cycle: low water and high water, in the Barcelos city and the riverine villages of Ponta da Terra, Bulixu, São Luiz and Cumaru. The fishers were orientated to identify the fishing grounds on the map and to estimate the frequency of fishing performed per local per season during the hydrological cycle.

Data analysis

The geographic coordinates of the fishing grounds were stored in Google Earth Pro software (version 7.1). Then, this information was converted to KML files for use in Q-GIS software (version 2.18), where these files were changed to shapefiles and the frequency of fishing-by-fishing ground was added using the dbf extension of the shapefiles. The kernel density estimation approach, that estimates the local intensity of an event scoring all the times this event occurs inside an area, was employed to evaluate the intensity of commercial fishing at each fishing ground per season of the

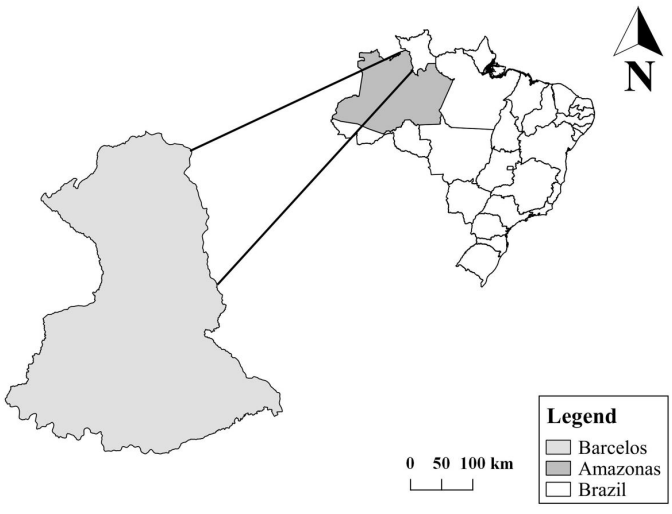

Figure 1. Location of the study area.

hydrological cycle. A radius of 3 km was assigned as the area to avoid over positioning and to determine the correct identification of the fishing grounds. Water level information was obtained from the database of the Brazilian Agency of Water (abbreviated ANA in Portuguese). The database *Esri National Geography,* available at the plugin *Quick Map Service* do Q-GIS, was employed to build the maps.

RESULTS AND DISCUSSION

Twenty commercial fishers with extensive fishing experience in the middle Negro River basin were interviewed. They identified eight fishing grounds explored by the commercial fishing fleet in Barcelos: (1) the main stem of the Negro River; (2) the Aracá River; (3) the Demeni River; (4) the Itu River; (5) the Preto River; (6) the Arirahá River; (7) the Juvari River; and (8) the Quiuni River (Figure 2). Inomata and Freitas (2015) had already cited the Aracá, Demeni and Itu rivers as important rivers to the commercial fishery in this region. The number of exploited fishing grounds was different from that recorded by Silva (2011), who documented 120 fishing sites when interviewing 67 fishers in the municipality of Santa Isabel do Rio Negro. In addition, in the municipality of Coari, in the middle Solimões River, 221 fishing sites were recorded among rivers, lakes and streams, and lakes were the most used environments (Corrêa et al., 2012). The high level of empirical knowledge of small-scale fisheries has been described by several authors (Freitas et al., 2002; Begossi, 2004) and is the reason for a few preferential fishing grounds in a large area such as the middle Negro River basin. The fishers know certain areas in the river where target fish species are found, according to the local knowledge transmitted by generations (Ribeiro, 1995; Silva, 2011).

The predominance of rivers as fishing grounds could be due to the geomorphological characteristics of this region. The Negro River and its tributaries are ancient rivers with well-defined channels with headwaters in the old areas of the Guyanna Plateau, exhibiting narrower floodplain areas than white water rivers (Ab'Saber, 2002). Nevertheless, the ecological behavior of the target species could also explain the predominance of river fisheries. This pattern was also observed on the low stretch of the Amazonas River (Isaac et al., 2004) and at the middle Madeira River (Cardoso and Freitas, 2007), but the opposite pattern, with a predominance of lake fisheries, was found in the middle Solimões River (Corrêa et al., 2012) and Juruá River (Alcântara et al., 2015).

The fishing intensity oscillated between 0 and 5.62 and between 0 and 5.79 in the low water and high water seasons, respectively (Figures 3 and 4). A greater number of fishing grounds were explored during the low water season than during the high water season. Possibly, this occurred because the dimensions of the aquatic environment diminish in the low water period and some places nearer the urban centers might become unavailable for fishing. Thus, fishers need to seek more fishing sites to obtain higher yields (Petrere, 1978; Begossi, 2001). In the high water period, with the elevation of the water level new habitats are formed and the fish disperse in the environment (Fink and Fink, 1978), so that

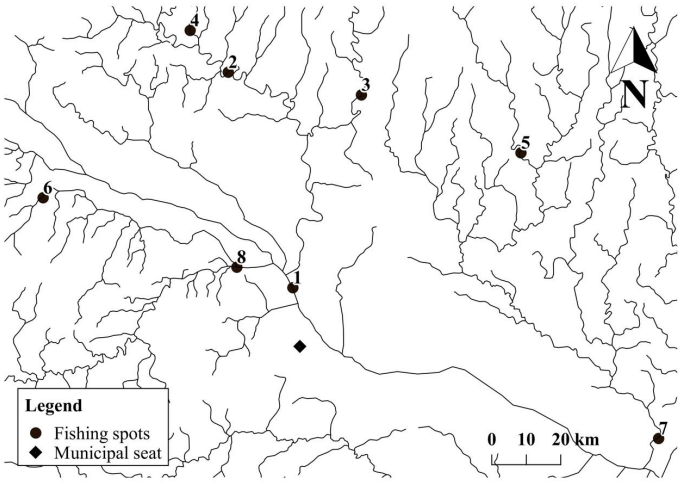

Figure 2. Places used for commercial fishing in Barcelos. (1) Negro River; (2) Aracá River; (3) Demeni River; (4) Itu River; (5) Preto River; (6) Arirahá River; (7) Jufari River; and (8) Quiuini River.

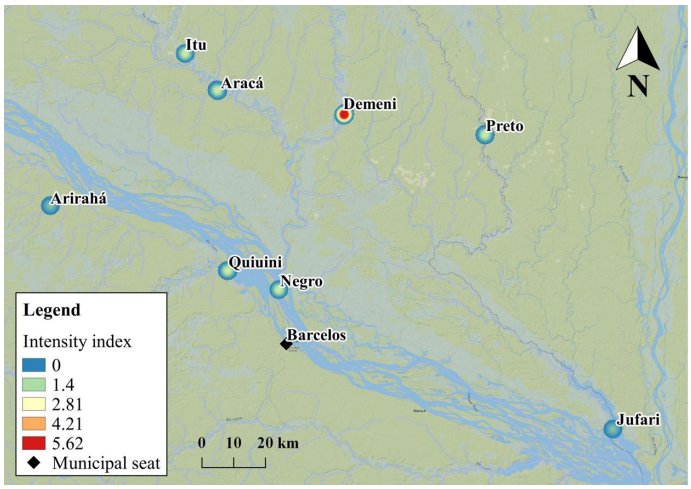

Figure 3. Intensity of commercial fisheries during the low water season in Barcelos.

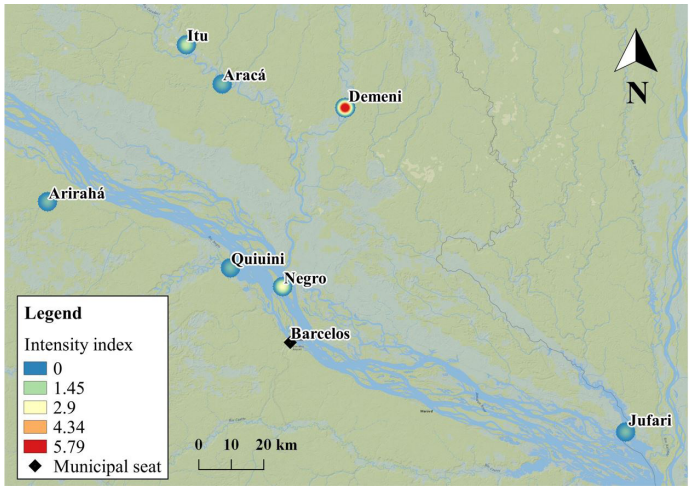

Figure 4. Intensity of commercial fisheries during the high water season in Barcelos.

fishers can exploit these resources more intensely. Several studies have shown the relationship between the hydrological cycle and Amazonian fisheries (Junk et al., 1989), including preferential fishing grounds and fishing gears (Freitas et al., 2002) and fishing yield (Isaac et al., 2016).

The abundance of fish in an area could be one factor explaining the fishing intensity (Silva, 2012). The Demeni River was the most explored river in both seasons of the hydrological cycle (Figures 3 and 4). This river shows limnological characteristics that are distinct from other rivers in the Negro River Basin. Its waters change from clear to white over the year, and there are several marginal areas that could act as a nursery for several fish species. As other oligotrophic rivers, the Negro River (Junk, 1979) has more productive tributaries that are unequally distributed along the river (Silva, 2011). Possibly the Demeni River can be considered one of these more productive tributaries, because the rivers of white waters are more fishy than those of black water. In addition, the Demeni River and Preto are one of the most important extractive areas of the piaçava in the middle Rio Negro and are also used for other activities such as agriculture and hunting (Silva, 2003).

Previous studies described the Demeni River as being very important to the local commercial fishery (Silva, 2003; Correia, 2014). This river is also heavily explored by recreational and subsistence fishers (Barra et al., 2010; Inomata, 2013; Correia, 2014), and some conflicts were related among them. The conflicts of the recreational fishers with subsistence and ornamental fishers are of lower intensity. In general, these conflicts are associated with spatial overlapping of activities. While with the commercial fishers, besides the spatial overlap, the conflicts are caused due to the distinct perception of the two groups on the target species *Cichla* sp. (Freitas and Rivas, 2006). In the middle Rio Negro, Silva (2003) also identified non-violent conflicts between subsistence, commercial and recreational fishers in the low water period, when spatial and temporal overlap are more intense.

This result shows that the spatial dynamics of the fisheries could be important for management proposals. Moreover, the fishing fleet dynamic, coupled with other indicators, could be useful to explain changes in the quantity and quality of production that may be motivated not only by the dynamics of fishing, but also by factors such as the environment use in conflict with other activities. A future analysis of the exploited species by fisher group could identify the conflict importance and, coupled with our results, support a sustainable and integrated strategy of fishing management for the middle Negro River.

REFERENCES

Ab'Saber, A.N. 2002. Amazônia brasileira: bases para o estudo dos ecossistemas da Amazônia brasileira. Estudos Avançados, 16(45): 7-30. **http://dx.doi.org/10.1590/S0103-40142002000200002**.

Alcântara, N.C.; Gonçalves, G.S.; Braga, T.M.P.; Santos, S.M.; Araújo, R.L.; Lima, J.P.; Aride, P.H.R.; Oliveira, A.T. 2015. Avaliação do desembarque pesqueiro (2009-2010) no município de Juruá, Amazonas, Brasil. Biota Amazônia, 1(5): 37-42. **http://dx.doi.org/10.18561/2179-5746/biotaamazonia.v5n1p37-42**.

Barra, C.S.; Dias, C.J.; Carvalheiro, K. 2010. Como cuidar para o peixe não acabar. São Paulo: Instituto Socioambiental. 70p. (Série Pescarias no Rio Negro).

Barthem, R.B.; Fabré, N.N. 2004. Biologia e diversidade dos recursos pesqueiros na Amazônia. In: Ruffino, M.L. A pesca e os recursos pesqueiros na Amazônia brasileira. Amazonas: IBAMA. p. 17-62.

Begossi, A. 2001. Mapping spots: fishing areas or territories among islanders of the Atlantic Forest (Brazil). Regional Environmental Change, 2(1): 1-12. **http://dx.doi.org/10.1007/s101130100022**.

Begossi, A. 2004. Áreas, pontos de pesca, pesqueiros e territórios na pesca artesanal. In: Begossi, A. Ecologia de pescadores da Mata Atlântica e da Amazônia. São Paulo: Hucitec. p. 223-255.

Caddy, J.F.; Carocci, F. 1999. The spatial allocation of fishing intensity by port-based inshore fleets: a GIS application. ICES Journal of Marine Science, 56(3): 388-403. **http://dx.doi.org/10.1006/jmsc.1999.0477**.

Cardoso, R.S.; Freitas, C.E.C. 2007. Desembarque e esforço de pesca da frota pesqueira comercial de Manicoré (Médio rio Madeira), Brasil. Acta Amazonica, 37(4): 605-612. **http://dx.doi.org/10.1590/S0044-59672007000400016**.

Corrêa, M.A.A.; Kahn, J.R.; Freitas, C.E.C. 2012. A pesca no município de Coari, estado do Amazonas, Brasil. Revista Brasileira de Engenharia de Pesca, 6(2): 1-12. http://dx.doi.org/**10.18817/repesca.v6i2.365**.

Correia, G.B. 2014. Dinâmica espacial da pesca em dois afluentes do médio rio Negro, Amazonas. Manaus. 92f. (Dissertação de Mestrado. Universidade Federal do Amazonas, CIPET). Available from: <https://tede.ufam.edu.br/handle/tede/6034> Access on: 14 oct. 2018.

Fink, W.I.; Fink, S.V. 1978. A Amazônia Central e seus peixes. Acta Amazonica, 8(4): 19-42. **http://dx.doi.org/10.1590/1809-43921978084s019**.

Fischer, C.F.A.; Chagas, A.L.G.A.; Dornelles, L.D.C. 1992. Pesca de águas interiores. Brasília: IBAMA. 32p.

Freitas, C.E.C.; Batista, V.S.; Inhamuns, A.J. 2002. Strategies of the small-scale fisheries on the Central Amazon Floodplain. Acta Amazonica, 32(1): 1-7. **http://dx.doi.org/10.1590/1809-43922002321108**.

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.

Gandra, A.L. 2010. O mercado de pescado da região metropolitana de Manaus. Montevidéu: Organização das Nações Unidas para a Alimentação e a Agricultura. 85p.

Goulding, M.; Carvalho, M.L.; Ferreira, E.G. 1988. Rio Negro, rich life in poor water: Amazonian diversity and foodchain ecology as seen through fish communities. Michigan: SPB Academic Publishing. 200p.

Inomata, S.O. 2013. Sustentabilidade ecológica e econômica da pesca comercial do município de Barcelos, região do médio rio Negro, Amazonas. Manaus. 72f. (Dissertação de Mestrado. Universidade Federal do Amazonas, CIPET). Available from: <https://tede.ufam.edu.br/handle/tede/2743> Access on: 17 sept. 2018.

Inomata, S.O.; Freitas, C.E.C. 2015. A pesca comercial no médio rio Negro: aspectos econômicos e estrutura operacional. Boletim do Instituto de Pesca, 41(1): 79-87.

Isaac, V.C.J.; Castello, L.; Santos, P.R.B.; Ruffino, M.L. 2016. Seasonal and interannual dynamics of river-floodplain multispecies fisheries in relation to flood pulses in the Lower Amazon. Fisheries Research, 183(1): 352-359. **http://dx.doi.org/10.1016/j.fishres.2016.06.017**.

Isaac, V.J.; Silva, C.O.; Ruffino, M.L. 2004. A pesca no Baixo Amazonas. In: Ruffino, M.L. A pesca e os recursos pesqueiros na Amazônia brasileira. Brasília: IBAMA/ProVárzea. p. 185-211.

Junk, W.J. 1979. Recursos hídricos da região amazônica: utilização e preservação. Acta Amazonica, 9(4): 37-51. **http://dx.doi.org/10.1590/1809-43921979094s037**.

Junk, W.J.; Bayley, P.B.; Sparks, R.E. 1989. The flood-pulse concept in river-floodplain systems. In: Dodge, D.P. *International Large River Symposium (LARS)*, Ottawa, 1989. Proceedings... Ottawa: Dept. of Fisheries and Oceans. p. 110-127. (Canadian Journal of Fisheries and Aquatic Sciences Special Publication).

Junk, W.J.; Piedade, M.T.F. 1993. Biomass and primary production of herbaceous plants communities in the Amazon floodplain. Hydrobiologia, 263(3): 155-162. **http://dx.doi.org/10.1007/BF00006266**.

Petrere, M. 1978. Pesca e esforço de pesca no estado do Amazonas. II: Locais e aparelhos, aparelhos de captura e estatística de desembarque. Acta Amazonica, 8(4): 1-54. http://dx.doi.org/**10.1590/1809-439219780832s005**.

Ribeiro, B.G. 1995. Os índios das águas pretas. São Paulo: Companhia das Letras. 270p.

Ruffino, M.L. 2005. Gestão do uso dos recursos pesqueiros na Amazônia. Manaus: IBAMA/ProVárzea. 135p.

Saint-Paul, U.; Bayley, P.B. 1979. A situação da pesca na Amazônica Central. Acta Amazonica, 9(4): 109-114. **http://dx.doi.org/10.1590/1809-43921979094s109**.

Santos, G.M.; Santos, A.C.M. 2005. Sustentabilidade da pesca na Amazônia. Estudos Avançados, 19(54): 165-182. **http://dx.doi.org/10.1590/S0103-40142005000200010**.

Silva, A.L. 2003. Uso de recursos por populações ribeirinhas do Médio Rio Negro. São Paulo. 220f. (Tese de Doutorado. Universidade de São Paulo). Available from: <http://bdpi.usp.br/single.php?_id=001341688> Access on: 20 oct. 2018.

Silva, A.L. 2011. Entre tradições e modernidade: conhecimento ecológico local, conflitos de pesca e manejo pesqueiro no rio Negro, Brasil. Boletim do Museu Paraense Emílio Goeldi. Ciências Humanas, 6(1): 141-163. **http://dx.doi.org/10.1590/S1981-81222011000100009**.

Silva, C.N. 2012. Geotecnologias aplicadas ao ordenamento territorial pesqueiro. Belém. 190f. (Tese de Doutorado. Universidade Federal do Pará). Available from: <http://repositorio.ufpa.br/jspui/handle/2011/3512> Access on: 23 oct. 2018.

Sousa, R.G.C.; 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. **http://dx.doi.org/10.1111/j.1439-0426.2010.01521.x**.