

LOW-COST TECHNOLOGY FOR FISH MONITORING APPLIED TO THE FISHING OF TWO SPECIES OF PACU IN AMAZONAS, BRAZIL*

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ABSTRACT

The present study aimed to investigate the “pacu” species’ commercialized in the “Colônia dos Pescadores Z-31” in the municipality of Humaitá, Amazonas State, from May 2018 to April 2019. For this purpose, we developed a method for raising a diary database in the colony, obtaining variables such as production, effort, catch per unit effort (CPUE), fishing spots, amongst others. We have identified two species of “pacu” - *Mylossoma aureum* and *M. duriventre* - with productions of 10.5 and 9.5 tonnes respectively which generated an income of U\$ 22,173.00. Captures occurred mostly randomly, due to the region’s fishing characteristics although the CPUE was higher when compared to bigger cities. We could also find evidence over their migratory cycles from a correlation between the catching sites and the period, where: i) during the falling water (May to July), the “pacus” start to leave the streams and concentrate in lakes; ii) during the dry season (August to October), the “pacus” perform a second migratory cycle, leaving streams and lakes and going to rivers; iii) finally, during the rising water, “pacus” once again move to small streams. The generated information can be used in fishing strategies in the region, reducing costs with inputs.

Keywords: Southern Amazon; artisanal fishing; fisheries management.

TECNOLOGIA DE BAIXO CUSTO PARA MONITORAMENTO DA PESCA, APLICADO A DUAS ESPÉCIES DE PACU NO AMAZONAS, BRASIL

RESUMO

O presente estudo buscou investigar quais espécies de pacu são comercializadas na Colônia dos Pescadores Z-31 no município de Humaitá, Amazonas, de maio de 2018 a abril de 2019. Para tal, foi desenvolvido um método para coleta diária de dados na colônia, o qual forneceu produção, esforço, captura por unidade de esforço (CPUE), locais de pesca, entre outros. Foram identificadas duas espécies de pacu *Mylossoma aureum* e *M. duriventre* com produtividades de 10,5 e 9,5 toneladas, respectivamente, o que gerou uma receita total de R\$ 100.000,00. As capturas ocorreram, na maioria dos casos, de forma aleatória devido às características da pesca regional, entretanto, os valores de CPUE se mantiveram acima dos encontrados em centros urbanos. Também foram encontradas evidências a respeito dos ciclos migratórios a partir da correlação dos locais de captura com os períodos de captura, onde: i) durante a vazante (maio a julho), os pacus começam a deixar os igarapés e passam a se concentrar nos lagos; ii) durante a seca (agosto a outubro), os pacus realizam um segundo ciclo migratório, deixando os igarapés e lagos para se concentrarem nos rios; iii) por último, durante a enchente, os pacus retornam para os pequenos lagos. As informações geradas podem ser usadas para nortear estratégias de manejo pesqueiro na região, diminuindo custos de produção.

Palavras-chave: Sul do Amazonas; pesca Artesanal; manejo Pesqueiro.

INTRODUCTION

Fishing is one of the most important human activities in Amazon, constituting a source of food, commerce, income and leisure for local populations, especially those living in the riversides of both large and small-sized rivers (Meggers, 1977). According to some authors (Cerdeira et al., 1997; Batista et al., 2004; Santos and Santos, 2005), fish consume index in the Amazon is one of the greatest in the world, varying from 369 g person⁻¹ day⁻¹ to 600 g person⁻¹ day⁻¹, which characterizes it as one of the main protein sources for locals. Considering that there are other sources of protein available, these

numbers represent a high consume index (around one fish person⁻¹ day⁻¹).

Among the most harvested species, the pacu (*Mylossoma* spp.) is one of the most captured in Brazilian Central Amazon. From Porto Velho (Goulding, 1979; Doria and Lima, 2008; Doria et al., 2012) to Manaus (Petreire Junior, 1978); and from smaller municipalities like Iranduba and Benjamin Constant (Doria et al., 2018) to bigger ones like Santarém (Isaac et al., 1996), the pacu is always one of the most captured species, demonstrating its commercial acceptance and economical importance.

However, lots of species from the sub-family Serrasalmidae (*Myleus* spp., *Mylossoma aureum* e *M. duriventre*, *Metynnis* spp.) are commonly known as “pacus”, being the “pacu manteiga” (*Mylossoma duriventre*) one of the most representative in landings at Porto Velho, as pointed by Doria and Lima (2008).

This fact, when considering monitoring points such as the Municipal Market of Humaitá, can prove to be an obstacle in the exact determination of which species of “pacu” are explored in the region since the providers for data survey are not concerned about a taxonomic differentiation and thus compromising a precise estimate.

Despite recent studies performed in the region (Sales et al., 2011; Lima et al., 2016), little is known about the “pacu” and its capture dynamics. This study is then an opportunity to expand our knowledge on the “pacu”, its bioecology and investigate the production from the artisanal fishing from the Middle Madeira in the adjacency of Humaitá municipality between May 2018 and April 2019 using low-cost social technology to achieve the data.

MATERIAL AND METHODS

The study area includes rivers, streams, and lakes around the municipality of Humaitá, Amazonas State, Brazil (Figure 1) located under coordinates 7°30'22”S and 63°01'15”W.

Considering the nature and territorial extension of the Middle Madeira Basin (Gibbs, 1967; Goulding et al., 2003; McClain and Naiman, 2008; Queiroz et al., 2013), and other similar regional studies (Sales et al., 2011; Lima et al., 2016), the authors opted for sampling in ports due to: convenience in data collection; logistics, since all catches should pass through the port (Fisherman’s Colony); and the already ongoing partnership between the LIOP (Madeira River Valley Laboratory of Ichthyology and Fishery Ordering) and The Colony.

The Colony in question (Z-31), accounts for nearly one thousand and five hundred associated fishermen and is located at the municipality of Humaitá, Amazonas. We - unlike Sales et al. (2011) and Lima et al. (2016), who obtained the data from the local market - obtained our data from daily monitoring the arriving boats in the rush hours (6 am to 9 am) with the aid of teams. For that purpose, we developed an adequate method for the local conditions, which is described below.

Each team responsible for daily data collection had four members with different duties during landings: a) the first one counted and took notes of the catches’ common names; b) the second one collected at least one representative individual from each species to take its biometric information (size and weight), paying attention to identify each individual according to the common name proposed by the first member; c) the third one took pictures of each representative individual and identified it according to its common name; and d) the fourth member

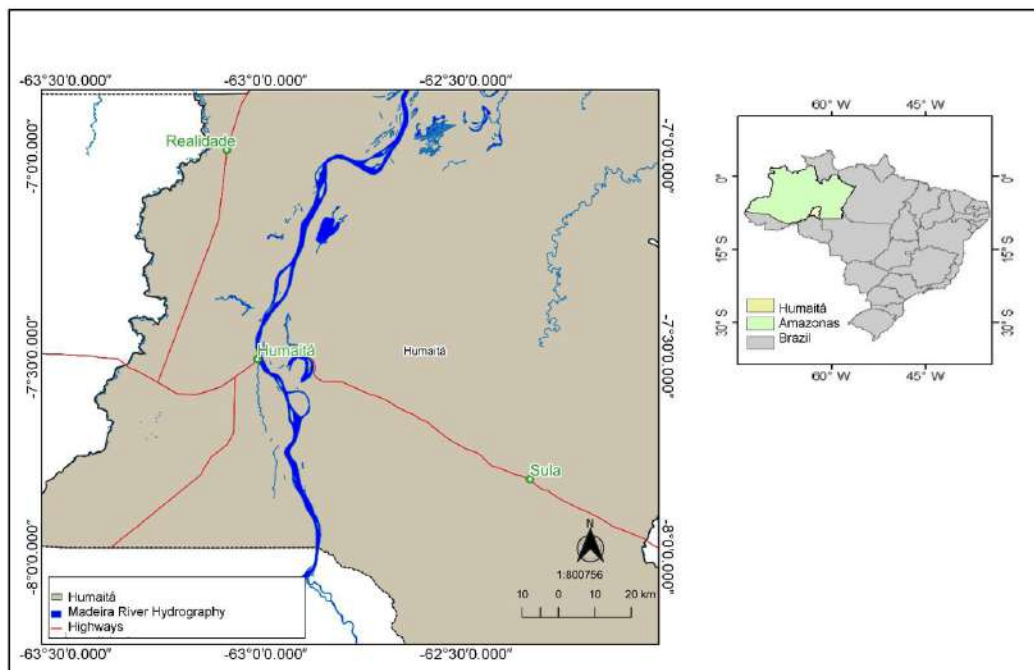


Figure 1. Location of the study area in the Madeira River basin, municipality of Humaitá, state of Amazonas, Brazil.

interviewed the owner of the fishing boat for the collection of socioeconomic and other useful information (days spent fishing, number of persons involved in the activity, when it happened, type of embarkation, description of the capture location, among others). Finally, all the data had been systematically written down with the aid of the landing form. Subsequently, in the lab, another team was responsible for analyzing the photographic records and to identify the collected specimens to the highest possible taxonomic level.

From that methodology, we were able to obtain: total number of captured individuals; weight; length; fishery production; the commercial value of each species; days spent fishing; the number of fishermen per boat; type of boat; and local of capture. Catch Per Unit of Effort (CPUE) was then estimated. All these variables were submitted to descriptive statistics with the aid of the R Software, defining mean, standard deviation (SD), maximum and minimal values, and the Coefficient of Variation (CV).

We obtained the Effort (Equation 1), the CPUE (Equation 2) and the CV (Equation 3) according to the following equations:

$$Effort = NDP \times NP \tag{1}$$

where: NDF is the number of days spent on fishing; and the NF is the number of fishermen involved

$$CPUE = \frac{Production(Kg)}{Effort} \tag{2}$$

$$CV = \frac{SD}{\bar{X}} .100 \tag{3}$$

where: CV is the coefficient of variation; SD is the standard deviation; and \bar{X} is the mean.

The authors opted for represent the variable “Effort” with the number of fishermen involved times the amount of days spent fishing, as recently used by Silva Junior et al. (2017), due to the difficult to extract information about how the fishing gears were used (number of repetitions and how long the remained in place), considering the used method to collect information. In addition to that, it is a classic method proposed by Petrere Jr. (1978), to measure “Effort”, especially when considering the Amazonas State particularities.

RESULTS AND DISCUSSION

During the study, we inventoried a total of 162 fishing boats with the presence of pacu. The total production for the pacu between May 2018 and April 2019 was approximately 20 tonnes, divided into two species: *Mylossoma aureum* and *M. duriventre*, with 10.5 and 9.5 tons respectively.

The mean production per boat along the year (Table 1) was 113.36 kg, with a CV of 173.12%. This low productivity associated to a high CV can be explained by two factors: a) the composition of the fishing fleet, which is composed predominantly by motorized canoes and a small parcel of fishing boats (Figure 2); and b) the non-selective fishing methods practiced by a considerable part of the fishers, which lands many species of low commercial value, commonly known as “salada”. The same explanation can be applied to the variable effort.

The information acquired corroborates other studies developed in the region by Sales et al. (2011) and Lima et al. (2016). The existence of two types of boats (small and big) (Figure 2), directly influence the transport capacity, which explains the maximum value of production (Table 1). The non-selective fishing explains the minimum production value (Table 1) since the captured pacu in these cases are the product of random captures (“salada”) (Lima et al., 2016). In other words, the local fishermen don’t go out to capture a specific specie, they capture whatever get caught in the mesh. This generates a great problem for the fishing monitoring in the region, once the disembarked fishes are composed by several species, commonly known as “salada”. In this light, the present method can be considered a success for managing to identify, at a taxonomic level, which species are being captured in the region. Despite only the “pacu” appear in this study, the data used is only a small cut of a bigger ongoing research.

The same explanation applies to the differences observed between the observed mean and CV for the variables Effort and CPUE (Table 1), in other words, the capacity of a canoe and a fishing boat to carry fishermen and fish varies significantly. Although, the mean value found for CPUE (24.25 kg fisherman⁻¹ day⁻¹) is still above the indexes found in bigger cities, such as Porto Velho, RO (upstream of Humaitá, AM), which is around 15±21 kg fisherman⁻¹ day⁻¹ (Doria and Lima, 2008), evidencing a high fishery production in the studied area, possibly for being a less explored region, when compared to the upriver capital. However,

Table 1. Descriptive statistics of the disembarked “pacus” (*Mylossoma* spp.) at the Fishermen Colony Z-31 from May 2018 to April 2019, Humaitá, Amazonas.

Variable	Mean	SD	CV (%)	Minimum	Maximum
Effort (fisherman day ⁻¹)	10.56	12.94	122.54	1.00	66.00
Production (kg)	113.36	196.25	173.12	0.26	1,545.00
CPUE (kg fisherman ⁻¹ day ⁻¹)	24.25	42.05	173.39	0.01	317.50
Price (USD)	1.14	0.57	11.18	0.66	1.55
Weight (kg)	0.35	0.11	29.50	0.14	0.80
Length (cm)	20.79	5.80	27.91	12.00	31.00

CPUE: Catch per effort unit; SD: standard deviance; CV: Coefficient of variation.

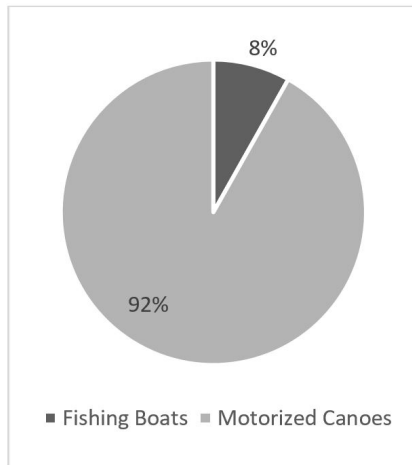


Figure 2. Composition of the inventoried embarkations with the presence of pacu (*Mylossoma* spp.) captured in the Madeira River, from May 2018 to April 2019, in the municipality of Humaitá, Amazonas.

when compared to other regions of the Amazon, the high values of CPUE do not reflect an expressive production (Petrere Junior, 1978; Goulding, 1979; Isaac et al., 1996; Doria and Lima, 2008; Doria et al., 2012, 2018) justified once again by the predominance of motorized canoes (Figure 2).

The pacu price did not vary significantly along the year, as stated by the low CV found for this variable (Table 1), but there are some variations related to the supply and demand relations, where the highest price (USD 1.55) occurs at the end of the closed season (around March), while the lowest price (USD 0.66) occurs when the supply overcomes the demand, at the beginning of the flood season (around May and April). Considering the mean price (USD 1.14), by multiplying it with the total production (≈ 20 t),

we have an approximated value of USD 22,173.00, once again, evidencing the socioeconomic importance of the pacu in the region.

Regarding the mean length, the observed values are inside the limits established by the decree IBAMA GEREX AM N° 01/2001, which defines a minimum capture size of 15 cm for the pacu. Despite the minimum value of 12 cm (1.23% of the landings), most captures respected the size established by decree, which is proved by the SD.

We noticed that the captured pacu concentrates in certain times of the year (Figure 3) associated with two hydrological periods: the beginning of the lowering water (May/July) and the final of the drought (August/October), corroborating with Doria and Lima (2008).

The predominant captures in specific periods can be associated with the reproductive ecology observed in some species of *Mylossoma*, which are short/medium migrators, typic from “várzea” systems (Cella-Ribeiro et al., 2016). This suggests that the capture peaks in the drought period (Figure 3) can be associated with the beginning of the migration period, which begins at the rising water. Despite classic literature consider October as a drought season, as pointed by Barthem and Goulding (1997), recent studies (Cella-Ribeiro et al., 2016) suggests that October characterizes the de beginning of the rising waters.

Consequently, the flood season presents the lowest production rates (Figure 3), once the fish shoals are in small streams and other flood environments for the spawning season. Finally, during the end of the drought and beginning of the lowering water, when the fish shoals return to the rivers after spawning, it’s possible to notice the return of captures, characterizing a second migratory cycle.

The evidence above is reinforced by the environments of catch along the year (streams, lakes, rivers, and igapó/várzea), which varied with the hydrological season (Figure 4).

The variation of capture environments (Figure 4) and the information provided by Cella-Ribeiro et al. (2016) about the ecology and biology of fishes from Madeira River, when used

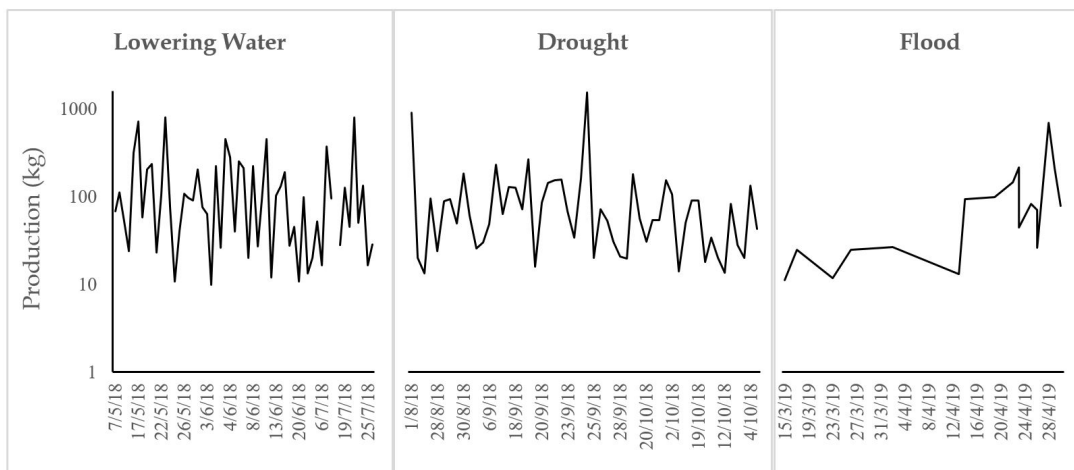


Figure 3. Pacu (*Mylossoma* spp.) captured in Madeira River, from May 2018 to April 2019 according to hydrological season (lowering water, drought, and flood), in the municipality of Humaitá, Amazonas.

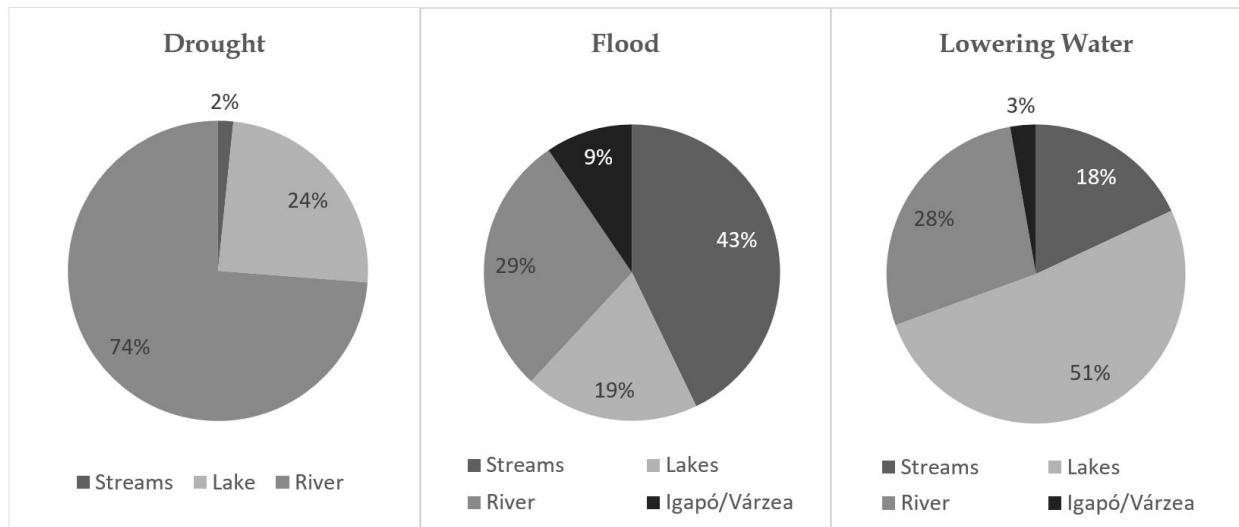


Figure 4. Environments of pacu (*Mylossoma* spp.) catch in Madeira River from May 2018 to April 2019 according to hydrological season (lowering water, drought, and flood), in the municipality of Humaitá, Amazonas.

together, allow us to trace the pacu migratory routes along the year, where: i) during the lowering water, the pacus that moved to small streams and flooded environments during the flood season begin to return to the lakes; ii) during the drought, the pacus perform a second cycle, moving from small streams and lakes to rivers; iii) at last, during the flood season (not present in this study due to the lack of information during the closed season), the fishes migrate once more to small streams and flooded environments.

The generated information about the capture environments according to the hydrological season, in addition to corroborating with research about fish ecology in the region, may also be used to orientate strategies to lower the input expenses of the activity. In other words, by knowing when and where a certain fish species will be in a certain period of the year, it is possible to lower the number of days spent on fishing, and consequently, expenses related to supplies (food, fuel, ice, etc.).

Finally, it is important to mention that the collected data used a social technology of low costs based on an experimental method adapted to local fishing reality. The present method integrated interdisciplinary participation of people from different social fields, such as the researchers, who elaborated the monitoring strategies; the fishermen, who provided the information; and students, who were responsible for the data collection and systematization.

CONCLUSIONS

During the study period, that occurred from May 2018 to April 2019, we identified two pacu species (*Mylossoma* spp.), which, combined, sum up a total production of 20 tons, where 10.5 tonnes are composed by *M. aureum* and 9.5 tonnes by *M. duriventre*.

The regional fishing is almost completely artisanal, with the predominance of motorized canoes with a high diversity of low commercial species commonly called “salada”. This, by its turn, drastically influenced the variables Effort, CPUE, and Production.

However, despite this high fishing variability, the CPUE kept above the levels found in studies performed in close urban centers, evidencing the conservation levels of the inventoried stocks.

We could also find a relation from the capture environments with the hydrological season, evidencing the pacu (*Mylossoma* spp.) cycles. This information can be used to orientate regional fishing strategies, enabling the application of the economics principle in the expanses with transportation, feeding, and storage of the product.

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REFERENCES

- Barthem, R.; Goulding, M. 1997. Ecologia, migração e conservação de peixes amazônicos. Brasília: Sociedade Civil Mamirauá, CNPq. 130p.
- Batista, V.S.; Issac, V.J.; Viana, J.P. 2004. Exploração e manejo dos recursos pesqueiros da Amazônia. In: Rufino, M.L. (Ed.). A pesca e os recursos pesqueiros na Amazônia brasileira. Manaus: Pro Várzea. p. 63-152.
- Cella-Ribeiro, A.; Torrente-Vilara, G.; Lima-Filho, J.A.; Doria, C.R.C. 2016. Ecologia e biologia de peixes do Rio Madeira. Porto Velho: EDUFRO. 305p.
- Cerdeira, R.G.P.; Ruffino, M.L.; Isaac, V.J. 1997. Consumo de pescado e outros alimentos pela população ribeirinha do lago grande de Monte Alegre, PA, Brasil. Acta Amazonica, 27(3): 213-228. <http://dx.doi.org/10.1590/1809-43921997273228>.
- Doria, C.R.C.; Lima, M.A.L. 2008. A pesca do pacu (Cuvier, 1818) (Characiformes: Characidae) desembarcado no mercado pesqueiro de Porto Velho (Rondônia), no período de 1985-2004. Biotemas, 21(3): 107-115. <http://dx.doi.org/10.5007/2175-7925.2008v21n3p107>.

- Doria, C.R.C.; Lima, M.A.L.; Angelini, R. 2018. Ecosystem indicators of small-scale fisheries with limited data in Madeira River (Brazil). *Boletim do Instituto de Pesca*, 44(3): e317. <http://dx.doi.org/10.20950/1678-2305.2018.317>.
- Doria, C.R.C.; Ruffino, M.L.; Hijazi, N.C.; Cruz, R.L. 2012. A pesca comercial na bacia do rio Madeira no estado de Rondônia, Amazônia brasileira. *Acta Amazonica*, 42(1): 29-40. <http://dx.doi.org/10.1590/S0044-59672012000100004>.
- Gibbs, R.J. 1967. The geochemistry of the Amazon river system. Part I. The factors that control the salinity and the composition and concentration of the suspended solids. *Geological Society of America Bulletin*, 78(10): 1203-1232. [http://dx.doi.org/10.1130/0016-7606\(1967\)78\[1203:TGO TAR\]2.0.CO;2](http://dx.doi.org/10.1130/0016-7606(1967)78[1203:TGO TAR]2.0.CO;2).
- Goulding, M. 1979. *Ecologia da pesca do Rio Madeira*. Manaus: INPA. 172p.
- Goulding, M.; Barthem, R.; Ferreira, E. 2003. *The Smithsonian Atlas of the Amazon*. Washington D.C.: Smithsonian Books. 253p.
- Isaac, V.J.; Milstein, A.; Ruffino, M.L. 1996. A pesca artesanal no baixo Amazonas: análise multivariada da captura por espécie. *Acta Amazonica*, 26(3): 185-208. <http://dx.doi.org/10.1590/1809-43921996263208>.
- Lima, M.A.L.; Freitas, C.E.C.; Moraes, S.M.; Doria, C.R.C. 2016. Pesca artesanal no município de Humaitá, Médio Rio Madeira, Amazonas, Brasil. *Boletim do Instituto de Pesca*, 42(4): 914-923. <http://dx.doi.org/10.20950/1678-2305.2016v42n4p914>.
- McClain, M.E.; Naiman, R.J. 2008. Andean contributions to the biogeochemistry of the Amazon river system. *Bioscience*, 58(4): 325-338. <http://dx.doi.org/10.1641/B580408>.
- Megggers, B. 1977. *Amazônia: a ilusão de um paraíso*. Rio de Janeiro: Civilização Brasileira. 207p.
- Petrere Junior, M. 1978. Pesca e esforço de pesca no Estado do Amazonas. *Acta Amazonica*, 8(3): 439-454. <http://dx.doi.org/10.1590/1809-43921978083439>.
- Queiroz, L.J.; Torrente-Vilara, G.; Vieira, F.G.; Ohara, W.M.; Zuanon, J.; Doria, C.R.C. 2013. Fishes of Cuniã Lake, Madeira River Basin, Brazil. *Check List*, 9(3): 540-548. <http://dx.doi.org/10.15560/9.3.540>.
- Sales, M.K.G.; Fonseca, R.; Zanchi, F.B.; Santos, S. 2011. Caracterização do desembarque pesqueiro efetuado na colônia de pescadores Z-31 no município de Humaitá-AM. *Revista Igapó*, 5(1): 33-52.
- 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 Junior, U.L.; Raseira, M.B.; Ruffino, M.L.; Batista, V.S.; Leite, R.G. 2017. Estimativas do tamanho do estoque de algumas espécies de peixes comerciais da Amazônia a partir de dados de esforço e captura. *Biodiversidade Brasileira*, 7(1): 105-121.