American Journal of Engineering Research (AJER)
E-ISSN: 2320-0847 p-ISSN: 2320-0936
Volume-8, Issue-2, pp-248-252
www.ajer.org
Research Paper Open Access

The fishing productivity of the Araguaia river, Tocantins, Brazil

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ABSTRACT :*The Araguaia River belongs to the second largest basin in Brazil and take place in an important transition zone betweenthe Cerrado and Amazon biomes. Despite the relative richness of ichthyofauna, the greatest challenge of artisanal fisheries is the widespread lack of landing information. Lack of knowledge about productivity leads to the myth that the degradation of fish stocks is caused by overfishing. The productivity of the gillnets was compared between drougth and rainy season in the Araguaia River, Tocantins, Brazil. Eleven fishing ground points were sampled with artisanal fishermen, monthly, during 2017 and 2018. 273 throw were carried out with gillnets of different meshes (7 to 22 cm knot to knot). The results indicated low CPUE indices and that there was no difference (P> 0.05) in productivity (kg/throw) and time per throw (hour) between drought (2.42 kg/throw) and rainy season (2,71 kg/ throw). Forage fish species predominated in catches, and meshes of size 11 cm was predominant. It is concluded that the greatest threats to fishing activity are not directly associated with fishing productivity. We also recommend the promotion of a broad debate with society about the future of fishery resources, so that the management process is more inclusive, with greater participation of fishermen. Finally, the Tocantins Araguaia basin encompasses 7.2 million people in 409 municipalities and artisanal fishing is one of the most important activities for maintaining food security, the economy and the culture of thousands of communities that depend on the river.*

KEYWORDS*artisanal fisheries, fisheries resources, public policies.*

Date of Submission: 15-02-2019 Date of acceptance: 28-02-2019

I. INTRODUCTION

Among the major challenges of artisanal fisheries is the widespread lack of landing information such as production, seasonality and georeferencing, especiallyin developing countries where there is a greater demand for food and weak government control over the management of fish stocks (Ramirez et al, 2017; Costello et al.; 2012 Salas et al., 2007). Brazil, even though it has a relative global presence in continental fisheries (13th producer in 2016) and the largest producer in South America (Funge-Smith, 2018), also has high per capita fish consumption rates in the Amazon basin (ISAAC and Almeida, 2011). However, there are still few government initiatives that systematically follow fish productivity.

In inland artisanal fisheries, the current information is limited to one-off production estimates based on fragile data. According to the FAO (2018), there was no production variation between 2015 and 2016 of this segment in Brazil. However, in fact, there was no collection of production data in that period due to a series of factors, the main one being the lack of governmentalattention to the sector. This fact demonstrates a scenario of neglect that also includes unsustainable policies with great potential for threat to biodiversity (Azevedo-Santos et al., 2017). Knowing productivity minimally, on an ongoing basis, is the firststep in driving good decision-making in fisheries management. In the state of Tocantins alone, fishing in the Araguaia River is carried out by a contingent of approximately 4,500 fishermen in 13 municipalities, operating in 2,100 small vessels (Silva and Faria, 2017) whose main fishing gear is the gillnet (Dias and Silva,2017.)

Although fishing represents a large socioeconomic role, in the food security and cultural heritage of thousands of riverine families, its productivity is unknown. That is, the realeffort employed in fishing and the volume captured is unknown. The lack of knowledge about fishery productivity leads to the myth that the degradation of fish stocks is caused by overfishing. In this sense, we aimed to know and compare the fishing productivity in the gillnets between the dry and rainy periods in the Araguaia river, Tocantins

II. MATERIALS AND METHODS

The study was carried in the municipality of Caseara, state of Tocantins, Brazil, in the channel and tributaries of the Araguaia River (Figure 1), located in the Araguaia-Tocantins Basin (second largest of Brazil). The Araguaia river basin has 382,000km^2 and 2,115km of extension from its source to its mouth and is inserted in an important transition zone between the Cerrado and Amazonia (Ferreira et al, 2011). It ischaracterized to be a plain river with low drainage density, low soil fertility and well distributed vegetation (Latrubesse and Stevaux, 2006). The predominant climate is subhumid, average temperature between 24.9 to 26.8^{o}C, mean precipitation of 1600 mm / year and extremely high erosion potential. Its biodiversity has a slight decrease and the fishery production provides adequate management possibilities (Ribeiro et al., 1995)

Expeditions with artisanal fishermen were monitored monthly between 2017 and 2018, during the drought period (March to October) and rainy (November to February), thus considering a year of fishing season. Productivity was classified according to the seasonality (drought and rainy). During the rainy season, the Araguaia-Tocantins basin has four months of fishing prohibition, between November and February (Brazil, 2011) to ensure the migration of fish (*piracema*). The classification of the drought and rain regime adopted is according to the Köppen-Geiger scale for the study region (Cardoso et al., 2014)

Eleven fishing points were sampled in the Araguaia and tributaries (Fig. 1). The vessels used to move to the fishing grounds are in aluminum with 6 meters in length. However, in the fishing operation a canoe is used in fiberglass or wood with 4.5 meters inlength and three crew members (one fisherman and two technicians). Gillnets of different mesh sizes, legally allowed for fishing, were used: 7, 8, 9, 10, 11, 13, 16, 20 and 22 cm knot to knot. The length of the nets varied between 10 and 280 meters, beingthe most used those of 60 and 100 meters (61.5% of the total) and height of 3 meters. The productivity was determined by the Capture by Unit of Effort (CPUE), main index of abundance in the fishing, as Kg/throw, being Throw is T = (Pt-Tt), where (T = Throw; Pt: Pick time; Tt: Throw time).The productivity and mean bid time were compared using Mann-Whitney non-parametric statistical analysis (significance level 0.05) for comparison of the means between drought and rainy periods. The different meshes size and the harvest of the main species captured were also analyzed.

III. RESULTS AND DISCUSSION

The diversity of species captured (Fig. 2) is a characteristic of artisanal fishing, especially in the case of rivers with low interference from hydroelectric dams such as Araguaia. This fact does not occur in dammed rivers, where one or two species predominate in the catches (Novaes and Carvalho 2009). However, the ichthyofauna of Araguaia-Tocantins is not especially rich considering the Amazonian patterns (Ribeiro et al., 1995), as it has about 300 species of fish cataloged (Santos et al., 1984), contrasting with 2,000 species in the Amazon (Roberts, 1972).

From the 273 throw, there was no significant difference (P>0,05)(between productivity per throw and average catch time between drought and rainy seasons (Table 1). The CPUEs of the drought and rainy seasons indicated a lower productivity in the gillnet, being 2.42 and 2.71 kg / throw, respectively. Regarding the species caught, there is no defined seasonality. However, some species are more abundant as *S. brama* (most captured), Serrasalmus sp., and Leporinussp) .Fig 3). Silva et al. (2017) suggests that Leporinussp may be harvested in the drought season, but without effort and catch information, only with reported data from fishermen's associations.Leporinusspand S. brama are forage species and naturally more abundant because they are fish at the base of the trophic chain (Pereira, 2010.)

However, the main issue is lack of basic and continuous information on production, which makes this sector "invisible" to public managers and society (Beard-Jr et al., 2016). InBrazil, artisanal fishing is little considered in natural resource management policies and it is common accusation that artisanal fishers are agents that negatively impact the environments in which they exploit. However, the low productivity and time per throw found in this work suggests that the negative impacts of this activity need to be relativized. Historically, artisanal fisheries have been adversely affected by political, institutional and economic factors, especially in developing countries (Cochraneand Doulman 2005). The inland fisheries still competes with other uses of the river basin (hydroelectric dams, irrigation, urban pollution, tourism, etc.), associated with low level of education of fishermen (Brazil, 2012), leaving them even more vulnerable to the interests of capital (Dugan 2005, Alan et al., 2005).

The debate on the effects of artisanal fisheries on environments is necessary, especially if we consider that illegal fishing is a global problem and affects both catch estimates in official statistics and recovery and maintenance of fish stocks (FAO 2002). Illegal fishing needs to be tackled, as it affects 30% of the world's fisheries (Agnew, et al., 2009) and occurs mainly in countries whose government does not have sufficient financial and human resources, like Brazil.

However, even with low yields identified in the Araguaia, a policy of monitoring landings in the basin is necessary to know the real impact and the effort employed in the long term fishing. Silva et al., 2017 suggest

the implementation of a integrated fishery monitoring plan, accompanied by a decentralized process of planning and execution with the fishing communities in the Tocantins-Araguaia basin.

The time of capture/throw (3.18h for the drought and 3.12h for the rainy season) suggests to be an attenuating factor with respect to the negative impacts of the catches. The fishermen of Araguaia report that they are forced to practice a short time of the throw due to the fast action of predators like the alligator (M. niger) and boto (*I .araguaiensis*) and fish of the genus Serrasalmus in the gill nets. In addition to eating the fish from the nets, they also damage the nets, causing economic losses to the fishermen. Therefore, the strategy of collecting fish before they are preyed out contributes to lower fishery productivity and consequently less impact on overfishing.In relation to the mesh size of the gillnets used, the M-11 (11 cm knot to knot)) were predominant regardless of the season (drought or rainy) (Fig 4), being this fishing gear the most suitable for forage species as *S. brama*.

IV. CONCLUSION

Considering the Araguaia River stretch studied the historic of lack of productive information about fishing and low productivity observed in the throw during the 2017/2018 fishery season suggests that the greatest threats to fishing activity are not directly associated with fishing productivity. In this sense, it reinforces the need for a monitoring plan for landings in the Tocantins-Araguaia basin.Another important issue to consider, besides alerting public managersto the importance of knowledge about fishery productivity in the Tocantins-Araguaia Basin, is to promote a broad debate with society about the future of fishery resources, so that the management process is more inclusive, with greater participation of fishermen.Although presenting a low population density (7.2 hab /km^2), the Tocantins Araguaia basin encompasses 7.2 million people in 409 municipalities. Artisanal fishing is one of the most important activities for the maintenance of food security, the economy and the culture of thousands of riverine communities that depend on the river.

ACKNOLEDGEMENT

The author acknowledges with thanks the contributions of all the fishermen from Caseara-Tocantins, who help us to carry out this study.

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Table I. Main indicators of fishing productivity between the drought and rainy season, in the Araguaia River, Tocantins.

Season	N throw	N ind. catch	Total (kg±SE[1])	CPUE (kg±SE[1])	time of capture/throw(hrs)
Drought (Apr-Oct)	143	2.959	346,92 ± 8,64	2,42 [a] ± 0,2	3,18 [a] ± 0,08
Rainy (Nov-May)	130	3.122	353,49± 6,54	2,71[a] ± 0,23	3,12 [a] ± 0,1
	273	6.081	700,41	-	-

[a]Equal letters do not differ between averages; [1] Standard error.

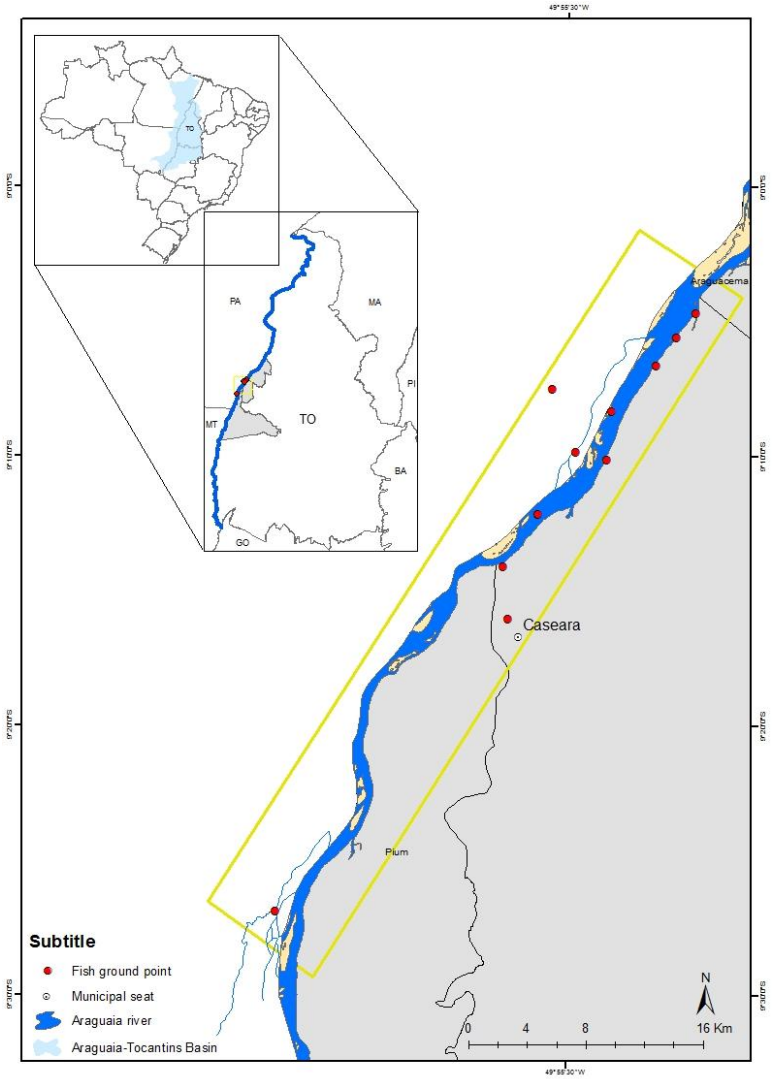

Figure 1. Fish ground points location in Araguaia river basin, Tocantins, Brazil

Leporinussp Semaprochilodusbrama Serrasalmussp

Figure 2. Some commercial species more catch in Araguaia river.

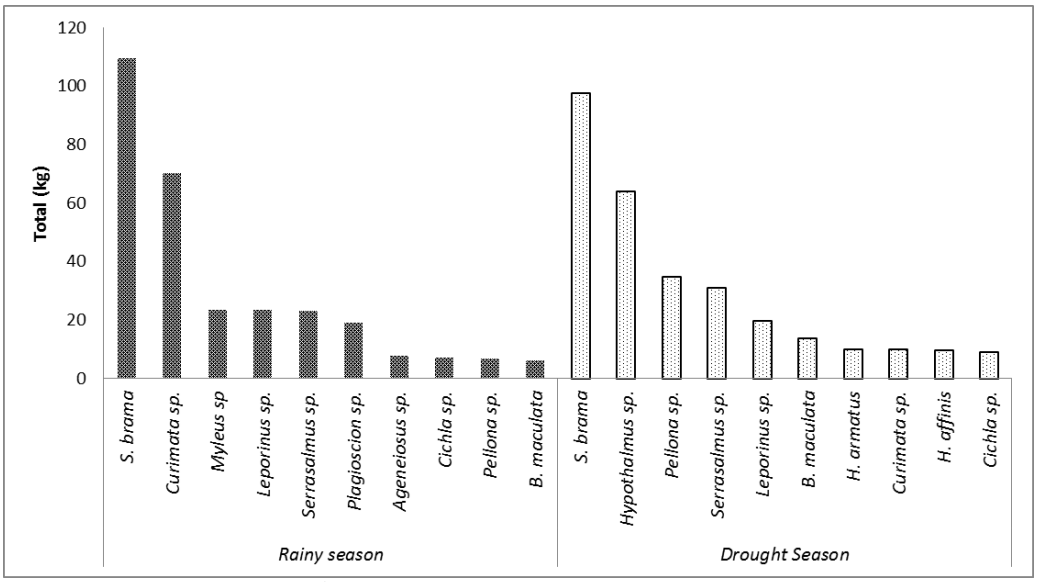

Figure 3.Occurrence of the main species catch (rainy and drought season) in Araguaia river.

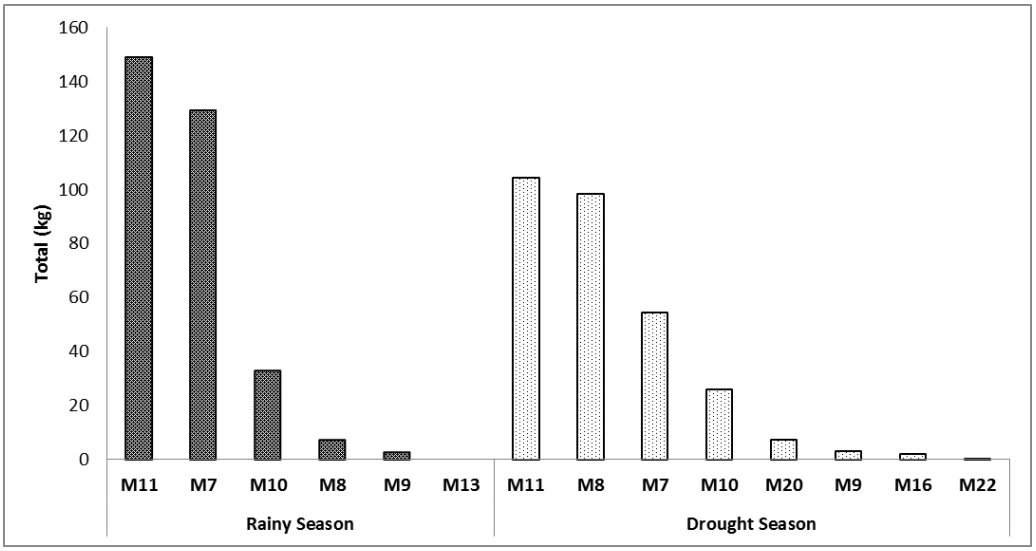

Figure 4. Production (kg) by mesh size and season of fish catch from Araguaia river, Tocantins, Brazil.

Adriano Prysthon" The fishing productivity of the Araguaia river, Tocantins, Brazil" American Journal of Engineering Research (AJER), vol.8, no.02, 2019, pp.248-252