CIÊNCIAeNATURA

UFSM

Ci. e Nat., Santa Maria v.42, e71, p. 1-19, 2020

DOI:10.5902/2179460X40186

ISSN 2179-460X

Environment Submissão 09/10/19 Aprovação 16/03/20 Publicação 09/09/20

Stock Assessment: Sustainable management in high and medium Araguari River, Amapá, Brazil

Avaliação de Estoque: Gestão sustentável no alto e médio rio Araguari, Amapá, Brasil

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ABSTRACT

Fisheries in Araguari river is an alternative income for families that depend on exploitation of natural resources. This study evaluates fisheries production in high and medium Araguari river to determine the bioeconomic reference points of fishery activities. Logbooks of fisheries were used from Fishermen Colony Z-16 from 2003 to 2010. The Maximum Sustainable Yield (MSY) and Effort at Maximum Sustainable Yield (fmsy) was: MSYSchaefer = 11246 kg and fmsy = 754 fisheries/year, and MSYFox = 11478 kg and fmsy = 1214 fisheries/year and at Bioeconomic Equilibrium (Eebe) Eebe = 10712 kg and Effort at Bioeconomic Equilibrium (febe) febe = 918 fisheries/year. The status of fisheries from Araguari River was declared as overfishing, and in this study, we found the same results. The Maximum Economic Yield (MEY) was reached, too, as the fisheries were at Bioeconomic Equilibrium (EBE). The fishery mortality (Fyear/Fmsy) and fishery effort (fyear/fmsy) trends show that from 2003 to 2009 the values were sustainable. In 2010 those trends became unsustainable, and the Maximum Economic Yield (MEY) for all years is unsustainable too. It is required this study be considered in future management agreements

Keywords: Surplus production models; Bioeconomics; Artisanal Fisheries; Fish mortality indexes

RESUMO

A pesca no rio Araguari é uma alternativa de renda das famílias que dependem da exploração de recursos naturais. Esse estudo avaliou a produção pesqueira no alto e médio rio Araguari para determinar os pontos de referência bioeconômicos da atividade pesqueira. Foram utilizados os registros das pescarias realizados pela colônia de pescadores Z-16 de 2003 a 2010. O rendimento máximo sustentável (MSY) e o esforço no rendimento máximo sustentável (fmsy) foram: MSYSchaefer = 11246 kg e fmsy = 754 pescarias/ano e MSYFox = 11478 kg e fmsy = 1214 pescarias/ano e o Equilíbrio Bioeconômico (Eebe) Eebe = 10712 kg e Esforço em Equilíbrio Bioeconômico (febe) febe = 918 pescarias/ano. A pescarias no rio Araguari foi declarada como em sobrepesca de crescimento e nesse trabalho encontramos os mesmos resultados. O rendimento máximo econômico (MEY) já foi atingido também, e as pescarias encontram-se em Equilíbrio Bioeconômico (EBE). As tendências de mortalidade por pescado (Fyear/Fmsy) e esforço de pesca (ano/fmsy) mostram que de 2003 a 2009 os valores foram sustentáveis. Em 2010, as tendências se tornaram insustentáveis, e o máximo rendimento econômico

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(MEY) para todos os anos é insustentável também. É necessário nos futuros acordos de gestão para a região os resultados deste estudo sejam considerados.
Palavras-chave: Modelos de produção excedente; Bioeconomia; Pesca artesanal; Mortalidade por pesca

1 INTRODUCTION

Fisheries is an activity with significant tradition and relevant in the socioeconomic structure of the Amazonian population (SANTOS; SANTOS, 2005; ALVES et al., 2015; MAZUREK et al., 2017). Similarly, artisanal fisheries in Amapá state is essential, the state's coast has approximately 698 km with a lot of rivers and abundance in fisheries resources (VIEIRA, 2002; BRANDÃO; SILVA, 2008). The Araguari River is essential for artisanal and subsistence fisheries, those activities are practiced along all the river, but mostly in the high and medium parts of the Araguari River, in a Conservation Unit called National Forest of Amapá – FLONA Amapá (ICMBIO, 2011).

The FLONA-AP and its surrounding area represent a valuable alternative of income for a large number of families living on the exploitation of natural resources. For this reason, these areas have been suffering an intense anthropic pressure due to fisheries, strongly stimulated by the proximity of cities such as Porto Grande, where fishers commercialize fish in fairs and local markets (CUNHA, 2017; SOARES et al., 2012; SANTOS et al., 2016). Thus, fisheries in the Araguari River is characterized as an activity of relevant social, cultural, economic and survival roles for the local population. In addition to fish, the Araguari River also integrates the Growth Acceleration Plan - PAC with at least five hydroelectric dams to be consolidated in the river, and three already in operation (ECOTUMUCUMAQUE, 2011, 2013). The EIA/RIMA and the Basic Environmental Plan - PBA (ECOTUMUCUMAQUE, 2011, 2013) described a hydrological impact of the construction of UHE of Cachoeira Caldeirão on the high and medium Araguari River as inevitable, not significant, permanent and irreversible, with low mitigation capacity.

Despite the construction of UHEs, the potential and importance of fisheries for the region, the technical and scientific knowledge in the Araguari River is still incipient, with few studies addressing the evaluation of fisheries stocks (OLIVEIRA et al., 2013; OLIVEIRA et al., 2018; PRESTES et al., 2019), however, fisheries management needs necessary information that is provided by stock assessments. The surplus production models (SCHAEFER, 1954; FOX, 1970) have often been employed for using few parameters. These models are essential tools for assessing the level of exploitation of fisheries stocks (WORM; BRANCH, 2012), as they allow estimating the available volume to fisheries through an approach centered on the economic viability of fish and stock support capacity (BENTES et al., 2011; BARRETO et al., 2016). Both models, Schaefer and Fox were used by Oliveira et al. (2013) in the Medium Araguari River, with indications that stocks have reached the maximum sustainable yield.

In this context, the present study proposes to evaluate fisheries stocks using the surplus production model, as well as to determine the sustainability indicators of artisanal fisheries in the Araguari River answering the following question: what is the level of fisheries production in the High and Medium Araguari River that is biological and economically viable? To elucidate this issue, it is necessary to use fisheries assessment and management tools, considering the economic aspects of fisheries activity (revenue and costs), and, how is the relationship between maximum biological yield and economic aspects of the activity.

2 MATERIAL AND METHODS

2.1 Study area

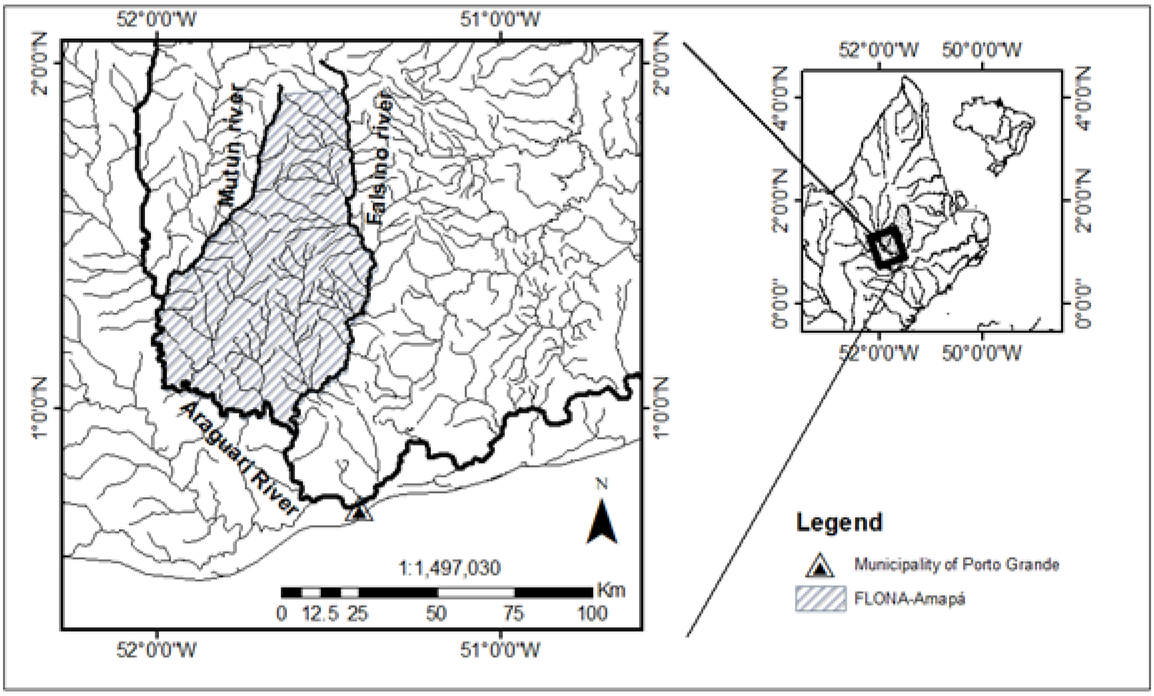
The study was carried out within and outside the Sustainable Use and Conservation Unit (UCs), National Forest of Amapá-FLONA-AP (North between the coordinates 51º30’25”W and 1º51’42”N, and South between 51º35’41”W and 0º55’27”N) (BÁRBARA, 2006; ICMBIO, 2011; IEF/SEMA, 2014) which is bathed by the Araguari River (High and Medium). The Araguari River basin is the largest and most important basin of the Amapá state, born in the Serra do Tumucumaque and has 617 km of extension to its mouth, in the Atlantic Ocean (CUNHA et al., 2004). Conceptually, it is divided into High (132 km), Medium (161 km) and Low Araguari River (205 km) (CUNHA, 2009). The

FLONA-AP has a territorial area of 4,120 km² and FLOTA-AP has a larger area, approximately 23,000 km². However, for this study, only one section corresponding to the limits of the Medium Araguari River (Figure 1) was selected.

The climate in the region, according to the Köppen classification, is tropical hot humid type, with rainfall in all seasons of the year (IEF/SEMA, 2014; ICMBIO, 2016). The average temperature is around 24 - 27.5 ºC, being October the month with higher temperatures and February to April the lowest (OLIVEIRA et al., 2010; IEF/SEMA, 2014). The relative humidity of the air can reach 80% between January and July (ICMBIO, 2016). The average annual rainfall is about 2289 millimeters, with a rainy season (January to June), and drought (July to December) (CUNHA et al., 2014). The Araguari River is characterized as having clear water (SIOLI, 1984). The amount of suspended particles carried is small and can present high visibility, greater than 4 meters; pH varies from 4 to 7 and conductivity of 6 or greater than 50 (BÁRBARA et al., 2010).

The fisheries activity exerted in this region is artisanal, the fishermen who work in this area reside in the area of FLONA-AP and the city of Porto Grande and are affiliated to Fisheries Colony Z-16 (SOARES et al., 2012; CUNHA, 2017). They use small wooden boats, with stern outboard motor, and appropriate to cross the rapids typical of this stretch of the Araguari River. The gear used are gill net, fishhook of various sizes to catch Hoplias aimara (Valenciennes, 1847) (trairão), Tometes trilobatus Valenciennes, 1850 (curupeté), Myloplus sp. Gill, 1896 (pacu), Myloplus asterias Muller; Troschel, 1844 (pacu), Myloplus ternetzi (NORMAN, 1929) (pacu) (SOARES et al., 2012; OLIVEIRA et al., 2013; SANTOS et al., 2016; CUNHA, 2017).

Figure 1. Geographic location of the Araguari River and Conservation Units, National Forest of Amapá (FLONA-AP) in the state of Amapá, Eastern Amazonia, Brazil



Source: authors

2.2 Data collection

The fisheries maps used in the study were obtained in Colony Z-16 and elaborated by the fishermen who work in the High and Medium Araguari River, located in the Central-East region of the Amapá state (Figure 1). We analyzed 646 fisheries maps relative to the years 2003 (17 maps), 2005 (17 maps), 2006 (56 maps), 2007 (95 maps), 2008 (132 maps), 2009 (59 maps) and 2010 (270 maps), as a way to prove fishing and receive safe insurance. Fisheries activity of Z-16 is restricted to a small part of the Araguari River (up to the Mutum River) and other tributaries (Figure 1). In this course of the Araguari River, around 11 species are exploited by fishermen H. aimara, Leporinus melanostictus Norman, 1926 (aracu), T. trilobatus, Boulengerella cuvieri Spix; Agassiz, 1829 (pirapucu), Myloplus sp. (pacu), M asterias (pacu), M. ternetzi (pacu), Ageneiosus inermis (Linnaeus, 1766) (mandubé), Triportheus brachypomus Valenciennes, 1850 (sardine), Serrasalmus rhombeus (LINNAEUS, 1766) (piranha-preta), Acestrorhynchus microlepis (Jardine, 1841) (uéua) and Acestrorhynchus falcatus (BLOCH, 1794) (uéua).

2.3 Data analysis

In this study, only the surplus production models of Schaefer (1954) and Fox (1970) were used. In the Schaefer model, the data of capture per unit of effort (CPUE) and capture (kg or ton.) were used in the following yield formula: Y = a*f+b*f2 (1) (SPARRE; VENEMA, 1997) where: Y = fisheries yield or total capture; a and b = coefficients obtained from linear regression between effort and capture per unit of effort; f = fisheries effort. The maximum sustainable yield and maximum sustainable effort values were calculated from the following models: MSY = a2/4b (2) and Fmsy = a/2b (3) (SPARRE; VENEMA, 1997) where: MSY = Production at maximum sustainable yield; Fmsy = Effort at Maximum Sustainable Yield; a and b = coefficients obtained from linear regression.

The Fox model used the following yield model: Y = f*ea+b*f (4) (SPARRE; VENEMA 1997) where: Y = fisheries yield or total capture; f = fisheries effort; a and b = coefficients obtained from linear regression.

The values of maximum sustainable yield and maximum sustainable effort in the Fox (1970) model are based on the following models: MSY = 1/b *ea-1 (5) and Fmsy=-1/b (6) (SPARRE; VENEMA, 1997) where: MSY = Production at Maximum Sustainable Yield; Fmsy = Effort at Maximum Sustainable Yield; a and b = coefficients obtained from linear regression.

The sustainable yield curve in function of effort is the basis of the Gordon (1954) model, which derives the yield function incorporating the economic components, price = p, and cost per unit of effort = TC as constant parameters (ANDERSON; SEIJO, 2010). As the total cost and revenue vary with the effort or size of the stock, respectively, there is: TSRe = p*(a*E-b*E2) (7), where TSR = Total sustainable revenue; p = price, a and b = values of regression between effort and capture per unit of effort according to Schaefer model. The Total Cost – TC is a function of the effort TC = Ce*E (8) where: TC = Total Cost; Ce = Cost per unit of effort; E = effort. Production at maximum economic yield is Emey= p*a-Ce/2*p*b (9) where: Emey = Production at maximum economic yield; p = price per kilo (R$); Ce = cost per unit of effort; a and b = values of the regression between effort and capture per unit of effort according to

Schaefer model. The production at bioeconomic equilibrium Ebe will be twice the production at maximum economic yield Emey according to Anderson and Seijo (2010).

Finally, sustainability indicators (LAXE, 2002) utilized from ocean fisheries to inland fisheries were used in relation to three reference points: Emey (Production at the point of maximum economic yield) is the reference indicating the level of biomass considered appropriate for achieving the best economic yield of fisheries; Ymsy (Production at the point of maximum sustainable yield) is the reference indicating the lowest level of biomass compatible with the sustainability of the resource (Table 1).

Table 1. Criteria and indicators for assessing the sustainability of continental fisheries, where: Fyear = mortality per fishery/year, Fmsy = mortality per fishery at maximum sustainable yield, fyear = fishery effort/year and, fmsy = fishery effort at maximum sustainable yield, Fmey = mortality per fishery at maximum economic yield, € = net income (R$), C = total capture (kg)

Criteria	Pressure MSY (F_{year}/F_{msy})
Sustainable	0.0 ⊢ 0.8
Good	0.8 ⊢ 1.0
Medium	1.0 ⊢ 1.3
Bad	1.3 ⊢ 2.0
Unsustainable	≥ 2.0

Source: Models utilized from ocean fisheries to inland fisheries described by FAO (1999) and Laxe (2002).

3 RESULTS AND DISCUSSION

The yield of fisheries in the Araguari River, regardless of model used, is already decreasing, i.e., the fishery effort practiced by fishermen of Z-16 is already negatively affecting fisheries stocks. The production values at Maximum Sustainable Yield (MSY) and Maximum Sustainable Effort (fmsy) were respectively: SchaeferMSY = 11246 kg and fmsy = 754 fisheries/year, and FoxMSY = 11478 kg and fmsy = 1214 fisheries/year. Although the observed data of the fisheries do not accompany the behavior of the graphs, which show indications of overfishing, the tendency of the fisheries yield is the decrease, regardless of the model. The available and affordable biomass for species exploitation together from 2010 are below the maximum sustainable yield (MSY) (Table 2).

Table 2. Effort and capture values used to estimate Maximum Sustainable Yield - Ymsy and Maximum Sustainable Effort - fmsy by Schaefer and Fox models for the fisheries carried out in the period from 2003 to 2010 in the High and Medium Araguari River, Amapá state, Brazil

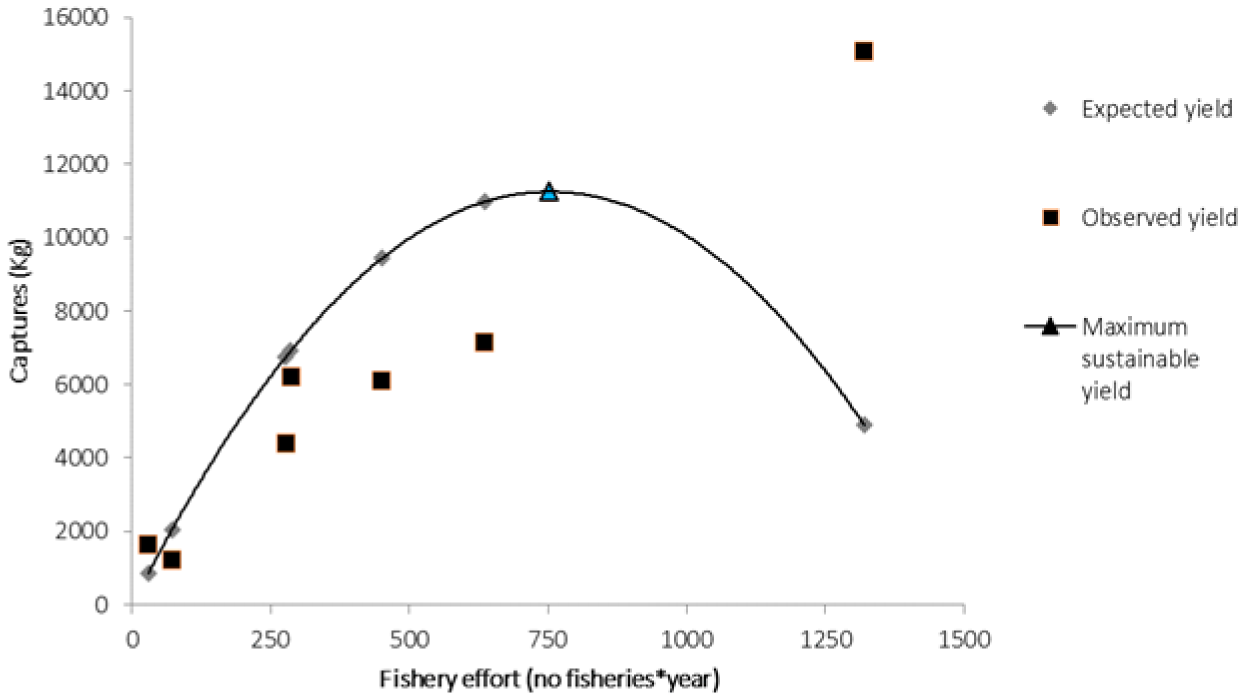
Year	**Capture (Kg of fish)**	**Effort (N of fisheries)**
I	**Y(i)**	**f(i)**
2003	1239	72
2005	1653	29
2006	4411	277
2007	6099	451
2008	7140	636
2009	6228	286
2010	15090	1320
Schaefer	MSY	11246 kg
Fox	MSY	11478 kg

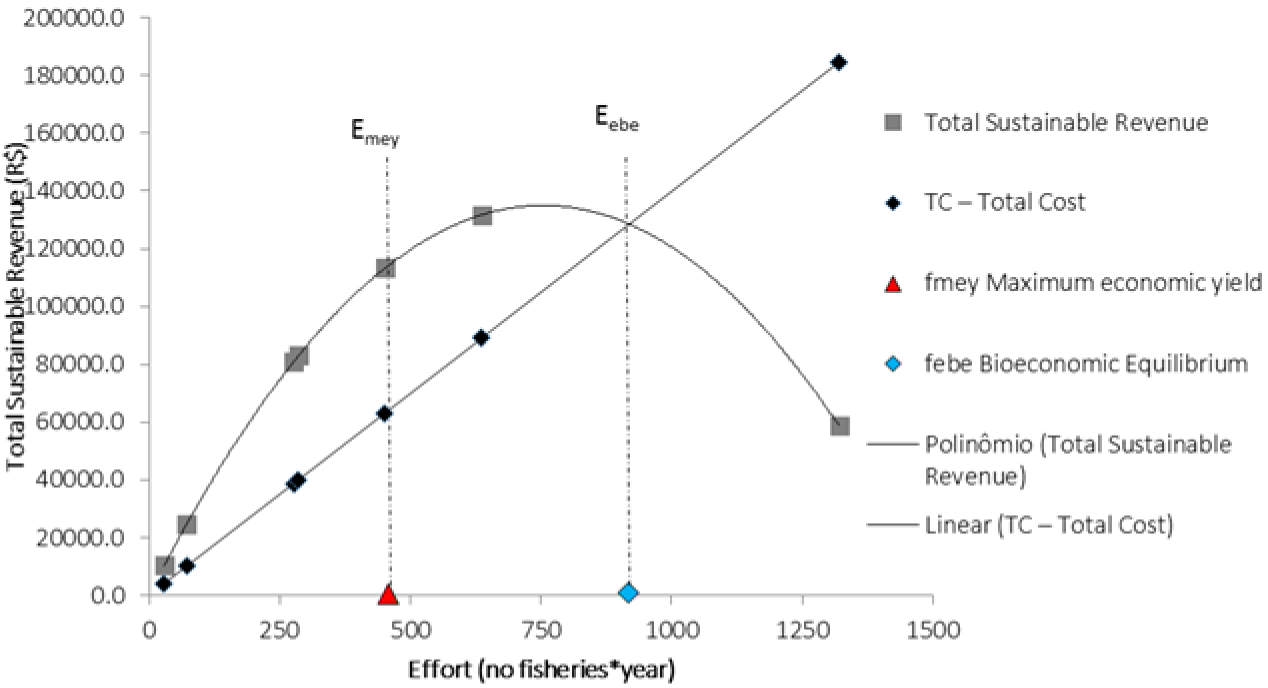
Source: authors

Figure 3A and B show the capture curve using the Schaefer model and its extension in the Graham-Schaefer bioeconomic model. The economic yield and costs (Figure 3B) in the Graham-Schaefer model show that the optimal economic range of fisheries is in the area between the total yield curve (TY) and the straight of the total costs (TC) up to the point of effort at Maximum Economic Yield (fmey) and Production at maximum economic yield (Emey) (fmey = 459 fisheries/year; Emey = 9526 kg), when the maximum economic yield is obtained.

The Production at Maximum Sustainable Yield (MSY) and the Effort at Maximum Sustainable Yield (fmsy) (fmsy = 754 fisheries/year, Ymsy = 11246 kg) are achieved between the points of Production at maximum economic yield (Emey) and Production at Bioeconomic Equilibrium Eebe (Figures 3A/B). In this area there is little loss of yield, but fishing is still viable. Beyond this point, revenue begins to drop as captures fall and costs continue to increase due to increased effort. In this scenario, capture tends to decrease regardless of the increase in effort, and fisheries enters the overfishing zone where there is a reduction in both yield and capture, reaching the point of Effort at Bioeconomic Equilibrium (febe) and Production at the Bioeconomic Equilibrium (Eebe) (febe = 918 fisheries/year, Eebe = 10712 kg), at this point the total yields are equal to the total costs and fishery is no longer a good business, discouraging the entry of new fishermen (Table 3; Figure 3B).

Figure 3. Bioeconomic analysis of fisheries carried out in the period from 2003 to 2010 in the High and Medium Araguari River, Amapá state, Brazil. A) Observed and estimated values of Maximum Sustainable Yield - MSY and Maximum Sustainable Effort - Ymsy by the Schaefer model. B) Observed and predicted values of Maximum Economic Yield -MEY and Total Cost-Effective Sustainable - TC by Schaefer model





Source: authors

Table 3. Biological, economic, and equilibrium parameters of fisheries carried out in the period from 2003 to 2010 in the High and Medium Araguari River, Amapá, Brazil

Biological Parameters	**Symbols**	**Values**
Linear regression intercept f/CPUE (Schaefer)	a	29
Linear regression slope f/CPUE (Schaefer)	b	-0.019
Economic Parameters		
Fish price	p	12.00 reais
Cost per unit of effort	Ce	20.00 per day of fishery
Equilibrium Values		
Maximum Sustainable Yield	Y_{msy}	11246 kg
Production at bioeconomic equilibrium	E_{ebe}	10712 kg
Production at maximum economic yield	E_{mey}	9526 kg
Effort at maximum sustainable yield	f_{msy}	754 fisheries/year
Effort at bioeconomic equilibrium	f_{ebe}	918 fisheries/year
Effort at maximum economic yield	f_{mey}	fisheries/year

Source: authors

Considering the criteria and reference indicators adopted to assess the sustainability of continental fisheries in the Araguari River, the sustainability values of fisheries in the Araguari River were similar, using both the Schaefer and Fox models (Table 4). Analyzing the standard indicators defined in the methodology, and comparing with those in Table 4, the pressure exerted based on mortality per fisheries (Fyear/Fmsy) and fishery effort (fyear/fmsy) in the years 2003 to 2009 could be considered sustainable. However, from 2010 there was a severe change, becoming unsustainable, where it was considered that available and accessible biomass would be at medium levels, and the effort practiced could already be considered bad, regardless of the models used. Pressure values at maximum economic yield (MEY) indicate that all years have economically unsustainable indices, only the year 2010 presented a change, rising to bad (1.6), because captures were much larger than the previous years. Regarding profitability, the years preceding 2010, the majority was seen as unsustainable since the net revenue value was lower than the costs incurred in the fishery activity.

In the fisheries carried out in the Araguari River, the Maximum sustainable yield (MSY) has already been reported as outdated (OLIVEIRA et al., 2013) and corroborated by the results presented here. We identified that the fishery effort increased over the years and the amount of fish decreased, reaching Maximum sustainable yield, setting fishery activity in this river in the overexploitation status. In addition, the Maximum Economic Yield (MEY) has also been exceeded, with fisheries heading towards the Bioeconomic Equilibrium (EBE). This occurred in the scenario from 2003 to 2010, when the fishermen of Colony Z-16 already faced problems such as: lack of infrastructure for the development of fisheries (SOARES et al., 2012), reduction of fishing area with the creation of integral protection area; and introduction of rules of conduct imposed by environmental bodies without the participation of fishermen (CUNHA, 2017; BRANDAO; SILVA, 2010).

In the last decade, the main problem faced by these fishermen was the transformations related to the implementation of Cachoeira Caldeirão hydroelectric power plant (CUNHA, 2017), which intensified the precarious socioeconomic situation experienced in the region. The average monthly income of fishermen working on the Araguari River is less than a minimum wage (SOARES et al., 2012; CUNHA, 2017), and considering the results of this study the situation of fisheries is reaching the condition of economically unfeasible.

It was possible to observe that, in the High and Medium Araguari River, the selling value of the kilo of fish does not vary much, however, the value of gasoline, which is the main fuel, presents enormous oscillations (SOARES, et al., 2012; CUNHA, 2017), as a consequence, in some moments the profits obtained from the fisheries can be larger or smaller. To simplify the calculations of the models, the prices of the fish kilo and costs were considered static and established by the mean between seasons. In the high and medium Araguari river, even with low economic incomes, fisheries is one of the only activities that fishermen play with mastery (CUNHA, 2017). The financial gain of fishermen is basically the income of fisheries, who seek to fish as much as possible to increase profitability, and considering the established partnership system the economic structure of fisheries is greatly strengthened by the relationship between those directly and indirectly involved in the activity (SOARES et al., 2012; CUNHA, 2017).

Table 4. Fisheries pressure value based on mortality per fisheries/year divided by mortality per fisheries at maximum sustainable yield (Fyear/Fmsy) and fishery effort/year divided by fishery effort at maximum sustainable yield (fyear/fmsy), Fmey = Mortality per fisheries at maximum economic yield, € = net income (R$), C = total capture (kg) of fisheries in High and Medium Araguari River between 2003 and 2010, Amapá state, Brazil

Years	**Pressure MSY (F_{year}/F_{msy}) Schaefer**
2003	0.11
2005	0.15
2006	0.39
2007	0.54
2008	0.63
2009	0.55
2010	1.34

* Bold values are between bad and unsustainable according to FAO (1999) modified by Laxe (2002)
Source: authors

Most fisheries are managed considering a combination of biological, economic, social and political goals (MARDLE et al., 2002; HILBORN, 2007), the need to determine the target of production in the light of economic, environmental and social considerations is recognised by groups discussing fisheries policies (XIMENES, 2008; AZEVEDO; PIERRI, 2013; FERREIRA; SILVA, 2017). However, how to define and balance these goals, maximizing the economic returns of fisheries is generally not discussed. Moreover, economic efficiency is a poorly understood concept by most political managers and also by many fisheries economists (BROMLEY, 2009). And, only recently the Maximum Economic Yield (MEY) began to be accepted as an critical and deployable goal in fisheries management (CAPELLESSO; CAZELLA, 2011; GUILLEN et al., 2015; CALDEIRA et al., 2016).

Estimates of MSY and MEY are generally not considered valid for many studies in multi-species, multi-gear, and multi-fleet fisheries. However, Guillen et al. (2013) assessed the MSY and MEY estimates in multi-specific and multi-gear fisheries compared to single-species assessments. The authors report better results when accounting for the multispecificity of the fleet for MSY and MEY. In this sense, the type of analysis made in this article is valid to guide the management of fisheries that occur in the High and Medium Araguari River and was performed for species together, because the data provided did not differentiate the species captured. Most fish stocks in the world are overexploited and therefore exploited beyond maximum sustainable yield (MSY) and maximum economic yield (MEY). The non-exploitation of fishing resources at MSY or MEY leads to loss of production and yield from fisheries, and the reality of fisheries is that most species are captured along with other species and by different fleets, in multi-species and multi-gear fisheries.

The indicators of sustainable development were developed by environmental managers, in the case of fishing stocks, with the main goal of maintaining the biomass within a level capable of supporting the optimum sustainable yield in relation to three reference points: BMEY (biomass at the maximum economic yield) is the reference indicating the level of biomass considered appropriate to obtain the best economic yield of fisheries; BMSY (biomass at the maximum sustainable yield) is the reference indicating the lowest level of biomass compatible with the sustainability of the resource; and BEBE (biomass at the bioeconomic equilibrium) is the reference showing the lowest level of biomass produced by overfishing and incompatible with the sustainability of the resource (GUILLEN et al., 2016; BASURTO et al., 2017), considering the indicators of sustainable development, the years of 2003, 2005, 2006, 2007, 2008 and 2009 present reference values that fall into sustainable fisheries. Only in 2010, the values change. Considering pressure at Maximum Sustainable Yield - MSY and Effort at Maximum Sustainable Yield - MSY, regardless of the model, all costs fall into a lousy fishery. The pressure at Maximum Economic Yied – MEY is also framed as bad for 2010, while profitability shows unsustainable fisheries values.

5 CONCLUSIONS

After all, what is the level of fisheries production in the High and Medium Araguari River, which is biological and economically viable? In the results presented, considering only biological data, the effort to be employed annually would be equal to 754 fisheries per year with Maximum Sustainable Yield of 11,246 kg. However, reviewing economic data, the values drop to 459 fisheries/year, with a total capture of 9,526 kilograms, which can extend to the effort at bioeconomic equilibrium 918 fisheries per year with Production at Bioeconomic Equilibrium of 10,712 kg of fish captured.

The MEY is a desirable ecological and economic goal for the management of sustainable fisheries in the Araguari River because the income of the accumulated resource in MEY generates the highest net revenue and results in the greatest return to society. At MEY, the yield is taller, the fishery effort is at its lowest value, and the total capture at MEY is virtually similar to EBE, the point at which the revenue is equal to the cost.

It is essential to mention that the parameters generated in this study can be used directly in the management of the fisheries stocks of the Araguari River, indicating the status of the fisheries and guiding decision-making. Mainly, considering the environmental impact caused in fisheries by the recent construction of the Cachoeira Caldeirão hydroelectric dam. This study serves as a reference for how fisheries worked before the implementation of this project. It is essential that it be used in future meetings to establish fisheries management now based on a quota of capture and effort, allied to the already existing in the region, which is mainly based on periods of prohibition of fishing. Moreover, it serves as a model for the management of fisheries activity for other rivers in the state of Amapá, as well as in Brazil.

ACKNOWLEDGMENT

Thanks to reviewers, collaborators, and development agencies.

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