

Original Article

Spatial distribution of the sport fishing in the state of Amazonas, northern Brazil

Distribuição espacial da pesca esportiva no estado do Amazonas, Brasil

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Abstract

The objective of this study was to spatialize sport fishing operations and assess the frequency of the use of the fishing areas in the state of Amazonas by combining the Geographic Information System (GIS) approach and information available in the documents sent to the Instituto de Proteção Ambiental do Amazonas (IPAAM). Information on sport fishing tourism operations was gathered from the IPAAM database and fishing licenses (FLs). Data analysis was conducted utilizing descriptive analysis, and the spatialization of the locations was performed using Q-GIS software. From 2002 to August 2021, 163 requests for FLs were made. There was a decrease in the amount of first time FL requests, with a peak in 2018 and 2019, N=17 and N=18, respectively. The activity is conducted in 24 municipalities, with Barcelos (31.36%) and Presidente Figueiredo (17.75%) being the most popular. At the sub-basin level, sport fishing is notably present in the Negro, Amazonas, Aripuanã, Madeira, Purus and Solimões River basins. Overall, 26.38% of operations take place in conservation areas, specifically in sustainable development reserves (SDRs). Barcelos recorded the largest number of rivers used, with 15 rivers. These results can support future proposals for the sustainable management of fisheries through the zoning of fishing areas in the state of Amazonas.

Keywords: fishing areas, spatialization, fisheries resources, fisheries zoning.

Resumo

O objetivo deste estudo foi espacializar as operações de pesca esportiva e avaliar a frequência de uso das áreas de pesca no estado do Amazonas, combinando a abordagem do Sistema de Informações Geográficas (SIG) e informações disponíveis nos documentos enviados ao Instituto de Proteção Ambiental do Amazonas (IPAAM). As informações sobre as operações de turismo de pesca esportiva foram coletadas na base de dados do IPAAM e dos Certificados de Registro de Pesca (CRPs). A análise dos dados foi realizada por meio de análise descritiva e a espacialização dos locais foi realizada por meio do software Q-GIS. De 2002 a agosto de 2021, foram feitas 163 solicitações de CRP. Houve uma diminuição na quantidade de primeiras solicitações de CRP, com pico em 2018 e 2019, N=17 e N=18, respectivamente. A atividade é realizada em 24 municípios, sendo Barcelos (31,36%) e Presidente Figueiredo (17,75%) os mais populares. Em nível de sub-bacias, a pesca esportiva está presente principalmente nas bacias dos rios Negro, Amazonas, Aripuanã, Madeira, Purus e Solimões. No geral, 26,38% das operações ocorrem em áreas de conservação, especificamente em Reservas de Desenvolvimento Sustentável (RDS). Barcelos registrou o maior número de rios utilizados, com 15 rios. Esses resultados podem subsidiar propostas futuras para a gestão sustentável da pesca por meio do zoneamento das áreas de pesca no estado do Amazonas.

Palavras-chave: áreas de pesca, espacialização, recursos pesqueiros, zoneamento pesqueiro.

1. Introduction

Sport fishing is an activity carried out in various parts of the world with the purpose of leisure and sport (Freire et al., 2020). With leisure's purposes, it could be performed with the procedure of catch and release or capture by quotas for fish of various species. It is estimated that about 10% of the world's population carries out this leisure activity, and it provides important social and economic benefits for those involved (Cooke and Cowx, 2004; Arlinghaus et al., 2019).

In Brazil, this activity has denominations that can vary between amateur, sports and recreational. Brazilian legislation establishes the definition “amateur” as a general denomination, while the terms “sport” is associated with catch and release, and “recreational” with quota for the catch (law 11,959/2009; Brasil, 2009a and Ordinance 4/2009; Brasil, 2009b); both are also widespread and used to refer to sport fishing.

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In general, despite being widely disseminated and having more than 200,000 fishers of this type in Brazil (Brasil, 2021), information on Brazilian sport fishing is related mainly to issues related to catch and release mortality (Chaves and Freire, 2012; Varandas et al., 2013; Thome-Souza et al., 2014; Lennox et al., 2015; Barroco et al., 2018; Sanches and Piana, 2020), to the socioeconomic profile of anglers (Condini et al., 2007; Harayashiki et al., 2011; Tsuruda et al., 2013) and to the evaluation of the stocks of target species (Pinheiro and Joyeux, 2015; Campos et al., 2020; Guabiroba et al., 2020; Giglio et al., 2020; Lubich et al., 2021). There is little information about spatialization and the frequency of use of fishing grounds by anglers (Pereira et al., 2019; Lopes and Freitas, 2019; Lopes et al., 2020, 2023).

In the state of Pará, in the northern region of Brazil, Valente et al. (2019) spatialized sport fishing and indicated that the activity occurred in only 26 municipalities, with a higher occurrence in the capital, Belém, on the Guamá River. For the same state, Rodrigues et al. (2020) identified the activity occurring in 22 municipalities, with the main interest in fishing being in the Mojuim and Mocajuba Rivers, which bathe the municipalities of São Joao da Ponta, São Caetano de Odivelas and Curuçá. These studies show either low or no use of other areas/municipalities within the territory of the state of Pará that have great potential for the development of the activity.

The state of Amazonas has great potential for the development of sport fishery in its territory since it presents a rich ichthyofauna and a wide variety of landscapes that provide tourist fishers with a unique experience of contact with nature (Silva and Lima, 2014). However, there are at least more three fishing modalities exploiting the Amazonian fishing resources: commercial, subsistence and ornamental and conflicts among them have been related in several localities (Freitas and Rivas, 2006). Due to the growth of sport fishing in the state, some regions have experienced conflicts between those involved in different fishing activities, which are mainly motivated by the common use of resources and territory, such happens at the Negro River basin (Sobreiro, 2015). This area involves fishers focused on commercial and sports fishing and who share use of the species of tucunaré (*Cichla* sp.) (Freitas and Rivas, 2006; Sobreiro and Freitas, 2008; Barra et al., 2010; Reis et al., 2022), but with different objectives and destinations for the captured fishes.

These conflicts and the increase in activity led to the implementation of legislation in 2018 that sort to regulate sport fishing operations in the state of Amazonas. Therefore, for companies to offer sport fishing packages, it is necessary for the entrepreneurs to obtain licenses for their operations, whether for boat-based hotels, lodges, jungle hotels, or floating hotels. Thus, before sport fishing activities begin, operating licenses must be requested. These licenses are provided by the Amazonas Environmental Protection Institute (IPAAM), which is the government agency responsible for control, monitoring, and regularization of environmental activities in the state of Amazonas. Requests must contain information about the nature of the enterprise, a description of the methods used for capturing fish, identification of the areas to be

explored, and mitigating measures to be adopted during captures (Decree 39.125/18; Amazonas, 2018 and Ordinance 070/19; Amazonas, 2019b). With the approval of the request, the companies may obtain fishing licenses (FL). The FL is valid for 365 days and allows the realization of sport fishing tourism within the area identified in the license. Its renewal is mandatory and must occur annually for the legal continuation of the activity in the state of Amazonas.

While there is a global argument associating the decline in fish stocks with commercial fisheries, recreational fisheries also have the potential to negatively impact fish and fisheries (Cooke and Cowx, 2004; Arlinghaus et al., 2019; Michailidis et al., 2020; Cooke et al., 2021b). Thus, spatial ecology in fishing provides crucial information about the population dynamics of fishery resources, essential for effective management and conservation of fish populations. As demonstrated by Garrone-Neto et al. (2018), who investigated the distribution of a highly targeted species by fishermen in the Southeast region of Brazil, *Centropomus parallelus*, it was found that this species had the ability to move across political borders between the states of Paraná and São Paulo. Based on their results, the authors recommended revising recreational fishing regulations in these two states to ensure effective conservation of the population. Additionally, understanding on its spatialization, the frequency of use of fishing grounds, and an analysis of the fishing operations growing can be essential in order to support and strengthen proposals for fisheries management, especially for the zoning of areas that involve different fishing modalities in the region.

The Geographic Information System (GIS) is one of the most commonly used tools to study and spatialize fishing sites (Caddy, 1999), and has been used mostly to analyze commercial fishing in different Brazilian states such as Pará (Pereira et al., 2019) and Amazonas (Lopes and Freitas, 2019; Lopes et al., 2020, 2023). Thus, the present study investigates the spatial distribution and frequency of use of fishing grounds by sport fishing operations in the state of Amazonas using the GIS approach. The results generated contribute to better knowledge of the activity and help to subsidize future proposals for the sustainable management of fisheries through zoning of fishing areas in the state of Amazonas.

2. Materials and Methods

The study was conducted in the state of Amazonas, in the northern region of Brazil. It is considered the largest Brazilian state in territorial area, with approximately 1,559,167.878 km², an estimated population of 4,269,995 inhabitants and demographic density of 2.23 inhabitants/km² (IBGE, 2021a). It is one of the main destinations for Brazilian and foreign anglers (Brasil, 2014; Amazonas, 2016) due to the diversity of fish species, aggressive behavior of some species and its variety of aquatic environments.

2.1. Data collection

Information on sport fishing tourism operations was obtained through a partnership with Fisheries Control

Management (FCM/IPAAM) and authorization to extract data from the database of the Instituto de Proteção Ambiental do Amazonas (IPAAM). Ipaam provides the licensing of sport fishing tourism operations under the responsibility of the Fisheries Control Management (FCM/IPAAM), which issues the fishing licenses (FLs) in the state of Amazonas.

For the study, the requests and the corresponding licenses conceded from January 2002 to August 2021 were analyzed. These documents were provided by the Fisheries Control Management office (FCM/IPAAM). Information was extracted regarding the number of requests submitted per year, and the municipalities and areas where sport fishing occurred.

2.2. Data analysis

The quantification of requests for FLs and non-renewal of the FLs by year was performed using descriptive analysis (Zar, 2010). The identification of the municipalities and locations where fishing took place were spatialized according to the geographical coordinates of the fishing grounds available in the FCM reports. In cases in which there were no coordinates, information from the IBGE database (IBGE, 2021b) and Venticinquê et al. (2016) was used to identify the municipalities and the river basin.

The Q-GIS software (version 2.18) was used for the construction of the maps, using hydrography and territorial limits data from IBGE (2021b). Usage frequency per municipality was added using the dbf extension in shapefiles. Spatialization of fishing sites at river level was conducted only in cases where there were two or more rivers identified.

3. Results

Applications for the fishing licenses (FLs) from the Instituto de Proteção Ambiental do Amazonas (IPAAM) for sport fishing began in 2002. From January 2002 to August 2021, 163 requests for FLs were made. Of this total, 94.48% of the requests were conceded regarding the FLs (88.34% for the realization of sport fishing tourism; 5.52% for the realization of a fishing tournament; and 0.61% for a commercial establishment specialized in fishing equipment) and 5.52% were not conceded because they were requests for which there was no continuity in the process, that is, the sport fishing operations companies only sent requests, but did not follow them up and/or respond to notifications, therefore, they did not receive a FL.

In 2002, twenty-two requests for FLs were made, of which six did not request renewal for continuation of the activity in the following year. In the other years, there was a decrease in the number of first-time requests for FLs, though the frequency increased again in the years 2016, 2018 and 2019 (Figure 1). Regarding the years in which there was an absence requests for renewals of FLs, the highest value was obtained in 2019, in which 22 operators did not request a renewal of their FL for operations in 2020 (Figure 1).

From the 163 requests for FLs, 116 requests identified the area where the sport fishing occurred, which were

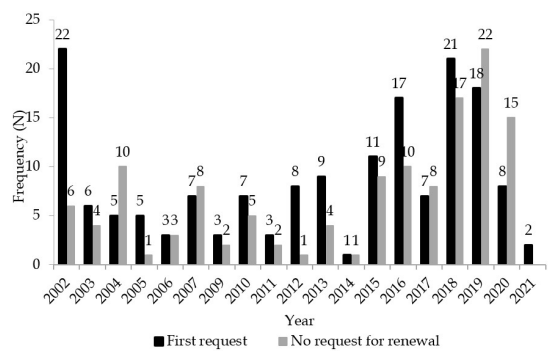


Figure 1. Frequency of the first request and no request for renewal of the fishing licenses from the Instituto de Proteção Ambiental do Amazonas (IPAAM).

43 requests for the realization of sport fishing tourism in conservation areas – sustainable development reserves (SDR) (Table 1), 59 with identification only at the municipal level, and 14 with more specific identification, including the geographic coordinates of the location or the rivers to be fished. From this information, 24 municipalities were identified where sport fishing tourism occurs in the state of Amazonas. The five municipalities with the highest request for the practice were Barcelos (31.36%), Presidente Figueiredo (17.75%), Itacoatiara (4.73%), Borba (2.96%) and Careiro (2.37%) (Figure 2). However, there were 47 requests in which there was no identification of the area of activity, which on the license only indicated the “state of Amazonas” or “state of Amazonas, not including protected areas”.

Sport fishing companies operate throughout the Amazon basin, exploring rivers with various water colorations, such as black, white, and clear waters (Figure 2). The activities are most frequent in the basins of the Negro, Amazonas, Aripuanã, Madeira, Purus, and Solimões Rivers, including some tributaries of these main basins (Figure 2).

The requests for licenses that indicated the specific areas to be fished, i.e., the river, were for fishing in the municipalities of Barcelos (N=8), Santa Isabel do Rio Negro (N=2), Borba (N=1), Manaus (N=1), Nova Olinda do Norte (n=1) and São Gabriel da Cachoeira (N=1) (Figure 3). Barcelos municipality (Figure 3B) presented the greatest number of rivers specified for fishing (N=15). However, two rivers are not within the territory of Barcelos: Preto River (which belongs to Santa Isabel do Rio Negro) and Jauaperi (belonging to Novo Airão), the latter also being mentioned in the license requests from Manaus (Figure 3C). A similar pattern is observed in requests from the municipality of Nova Olinda do Norte, where most rivers do not fall within the municipality’s territory, except for the Paraconi River, which is situated on its boundary (Figure 3A).

For the municipality of Borba, only the Abacaxis River was identified. In São Gabriel da Cachoeira, although three rivers (Marié, Turi and Rubo Rivers) were mentioned in the requests, only the Marié River is listed in the hydrographic data of the IBGE (2021b). The rivers fished in the municipalities of Santa Isabel do Rio Negro and São Gabriel da Cachoeira (Figure 3A) are located within

Table 1. Number of requests for fishing licenses (FLs) to carry out sport fishing tourism in conservation areas in the state of Amazonas. The Mamirauá sustainable development reserve (SDR) covers more than one municipality. In this case, a municipality with an asterisk (*) identifies where the operations are carried out.

Municipality	Sustainable development reserve (SDR)	Conservation area as a % of the municipality (%)	Number of requests (N)
São Sebastião do Uatumã	Uatumã SDR	59.07	33
Itapiranga		40.93	
Borba	Matupiri SDR	100	6
Novo Aripuanã	Juma SDR	100	1
Fonte Boa	Mamirauá SDR	52.36	1
Maraã		26.97	
Uarini*		18.28	
Japurá		1.4	
Tonantins		0.99	
Apuí	Bararati SDR	100	1
Anori	Piagaçu-Purus SDR	40.19	1
Tapauá		30.15	
Beruri		28.09	
Coari		1.57	
N total =			43

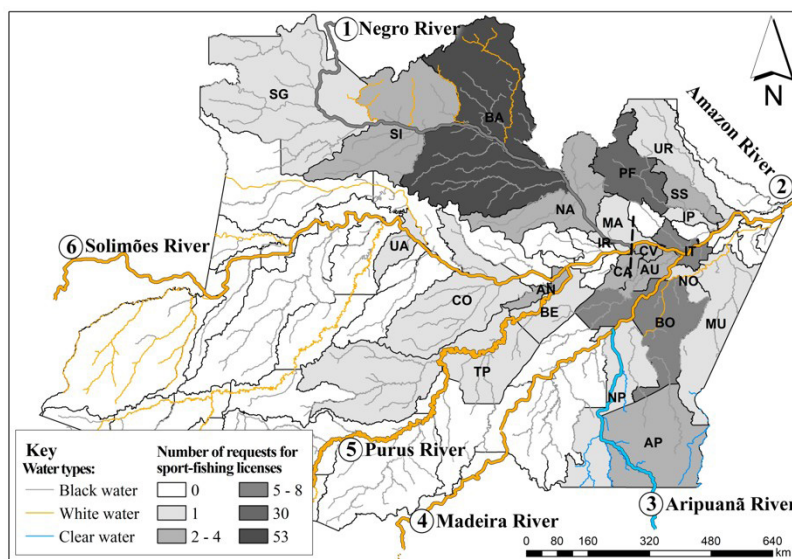


Figure 2. Identification and spatialization of the municipalities of the state of Amazonas according to the number of requests for fishing licenses (FLs) from the Instituto de Proteção Ambiental do Amazonas (IPAAM) to carry out sport fishing. AN= Anori; AP= Apuí; AU= Autazes; BA= Barcelos; BE= Beruri; BO= Borba; CA= Careiro; CV= Careiro da Várzea; CO= Coari; IR= Iranduba; IT= Itacoatiara; IP= Itapiranga; MA= Manaus; MU= Maués; NO= Nova Olinda do Norte; NA= Novo Airão; NP= Novo Aripuanã; PF= Presidente Figueiredo; SI= Santa Isabel do Rio Negro; SG= São Gabriel da Cachoeira; SS= São Sebastião do Uatumã; TP= Tapauá; UA= Uarini; UR= Uruará.

indigenous territories, as are the Canumã and Tupana Rivers in Nova Olinda do Norte (Figure 3D).

4. Discussion

Sport fishing tourism in the state of Amazonas should be licensed annually, through the request and renewal of the

fishing licenses (FLs), either for specialized companies or for holding fishing tournaments. The high number of applications for licensing in 2002, the first year of the historical series, could be explained by the need to regularization of several companies that were operating before the system of register be implanted. The subtle trend in the increase in the number of FL requests found in the next years until 2016, when it was not mandatory to submit reports provided for in state

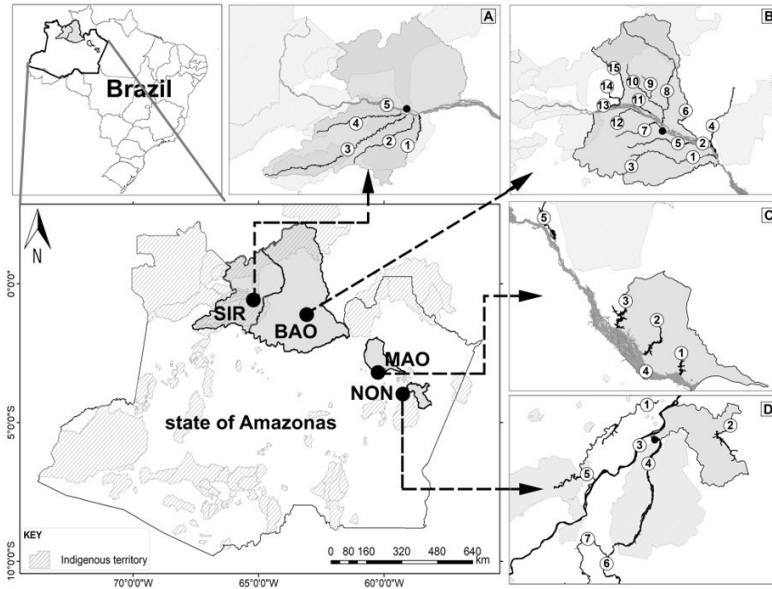


Figure 3. Spatialization of the rivers identified in the requests for fishing licenses (FLs) for sport fishing in four municipalities of the state of Amazonas, **(A) Santa Isabel do Rio Negro (SIR):** 1) Urubaxi; 2) Aiuanã; 3) Uneiuxi; 4) Téa and 5) Negro Rivers; **(B) Barcelos (BAO):** 1) Unini; 2) Negro; 3) Araras; 4) Jauaperi; 5) Caurés; 6) Jufari; 7) Cuiuni; 8) Demeni; 9) Aracá; 10) Curuduri; 11) Itú; 12) Ararirá; 13) Atauí; 14) Preto and 15) Padauri Rivers; **(C) Manaus (MAO):** 1) Tarumã; 2) Cuieiras; 3) Apuaú; 4) Negro; and 5) Jauaperi Rivers; **(D) Nova Olinda do Norte (NON):** 1) Araçá Grande; 2) Paraconi; 3) Madeira; 4) Canumã; 5) Tupana; 6) Sucunduri; and 7) Acari Rivers.

legislation (Decreets 39,125/2018; Amazonas, 2018 and Ordinance 070/2019; Amazonas, 2019b), can be explained by a number of issues: i) gradual availability of internet access in the municipalities of the Solimões-Amazon River channel from 2010 (Lima and Schor, 2008), and in the Negro River channel from 2012 (Soares, 2016), which provided greater dissemination of fishing packages through digital means, thus increasing the number of possible customers from different parts of the world; ii) gradual dissemination of the Middle Rio Negro region as an exceptional area to develop sports fishing and leisure activity; iii) encouragement and strengthening of the activity through the creation of the National Amateur Fishing Program (PNDPA) (Brasil, 2024), and iv) gradual adaptation and expansion of the operations, with the inclusion of other modalities of operation, such as floating hotels, jungle lodges and camps (Furtado, 2020; Lubich et al., 2023), which offered more options for fishers with different profiles.

The peaks in FL requests in 2018 and 2019 may reflect the implementation of state legislation (Decreets 39,125/2018 and Ordinance 070/2019; Amazonas, 2018, 2019b), which makes it mandatory to send reports (work plan and log) regarding operations. In the document, operators must present information related to personal data, characterization of the enterprise, operational methods, methods for monitoring the fish caught, operation locations, impacts, and mitigation measures. Compliance with these rules is now mandatory to the operation be certified and/or renewal granted.

However, annually there are companies that do not carry out a renewal of their FL, and no information about the reasons that lead operators not to request a renewal

was sent to IPAAM, leaving a gap in the process. The peak in non-renewal requests was most pronounced in 2019, possibly influenced by the global COVID-19 pandemic that began affecting the world in early 2020. The impacts of the coronavirus pandemic on world (Falcon et al., 2020; Lenzen et al., 2020; Cooke et al., 2021a), Brazilian (Clemente et al., 2020; Lamas et al., 2020; Mecca and Gedoz, 2020) and Amazonian (Menezes et al., 2021; Vidal et al., 2021) tourism has already been reported in the literature. These studies, in general, cite as some of the causes the suspension of some tourist sectors, the drop in the flow of tourists, the reduction in passengers at airports and bus stations, as well as the cancellation and postponement of trips, fairs and events.

Despite the pandemic in 2020, AmazonasTur (2020) cite that sport fishing was the strongest Amazonian tourism segment in this year. The continuity of the activity in the midst of the pandemic was also narrated to the coastal region of the state of São Paulo, although this occurred at a lower frequency and with fewer participants (Laurelli et al., 2021).

According to Cooke et al. (2021a), due to the lockdown period during the pandemic, there was an increase in the effort and exploitation of sport fishing around the world, as many people sought outdoor spaces and many countries encouraged sport fishing as a socially distanced activity. In North America, in 2020, about 90% of states did not suspend or delay the sport fishing season and places such as Arkansas, Kentucky and New York chose to encourage sport fishing during the pandemic, as long as it was carried out in compliance with the public health guidelines of each state (Paradis et al., 2021).

Although the state of Amazonas has 62 municipalities, only 24 (38.71%) are make requests for FLs for the legal practice of fishing tourism by operators. Similar patterns were found by Brasil (2014) and Amazonas (2016), which state that the sport fishing season affects 25 Amazonian municipalities, with the municipality of Barcelos being the main destination, as well as the municipalities located along the channel of the Negro River basin. Along the channel of the Negro River basin, the Marié (Barra, 2016), Urubaxi, Padauri, Aracá, Demeni, Cuiuni, Caures, Unini (Barroco and Freitas, 2014), Uneiuxi, Aiuanã, Preto, Itú (Furtado, 2020; Lubich et al., 2021) Caurés, Jufari, Curuduri, Atauí, Preto, Padauri (Lubich et al., 2023) rivers are already known as locations for sport fishing. Besides in the Negro River, sport fishing has been documented in the Madeira (Pinto et al., 2024) and Solimões River basins (Garcez et al., 2010). The preference for these areas can be attributed to the presence of species of tucunaré (*Cichla* sp.) throughout the Amazon basin, which is the main flagship of the activity and symbolizes sport fishing in the Amazon. According to Kullander and Ferreira (2006), seven species are distributed within the boundaries of the state of Amazonas.

As was found in the present study, there are reports in the literature of the occurrence of fishing activity in protected areas, such as in sustainable development reserves (Amazonas, 2019a) and in indigenous territories, in the municipalities of São Gabriel da Cachoeira (Barra, 2016) and Santa Isabel do Rio Negro (Lubich et al., 2021), which is a legally approved practice (Ordinance 91/2020, Brasil, 2020). However, it is important to mention that sport fishing in protected areas must adhere to the definitions of the National System of Conservation (law 9985/2000, Brasil, 2000). This activity is prohibited in areas of total protection, which are sites with significant biodiversity and whose purpose is the preservation of sensitive ecosystems. Nevertheless, the development of fishing tourism in protected areas should require infrastructure projected with low impact on the environment. Additionally, an increase in the number of anglers can put pressure on natural resources, leading to overfishing and ecosystem disruption and this fishing should be carefully managed.

The importance of the Negro River basin for sport fishing tourism is particularly evident, and this is due to the unique landscapes that are found in this region. These include the Serra do Aracá National Park, the Unini Extractive Reserve, and part of the Jaú National Park. The Mariuá Environmental Preservation Area is also located in this region and is considered the largest freshwater river archipelago in the world, with about 1,600 islands. In addition, there is the possibility of catching large specimens of tucunaré (*Cichla* spp.) and catfish (Siluriformes), and the municipality of Barcelos has been considered the international capital of sport fishing. In this region, the world records for weight and length of peacock bass (*Cichla temensis* Humboldt 1821) were broken in 2010 and 2015, and for butterfly peacock bass (*Cichla orinocensis* Humboldt 1821) in 2010 and 2019. These were all homologated by the International Game Fish Association (IFGA, 2021), a non-profit organization which recognizes fisheries and catch records by fish species and size, as well as by category of equipment used in fishing.

Due to the mandatory sending of reports of the fishing season by operators, provided for by law (Decreets 2,713/2001, 39,125/2018 and Ordinance 070/2019), these reports are and have been fundamental for identifying the most exploited places for the practice of fishing tourism. Based on this study, we recommend raising awareness among sport fishing entrepreneurs to operate legally under the supervision of environmental regulatory agencies. This not only helps avoid penalties but also demonstrates environmental responsibility, providing greater safety for fishers. Regions that experience heavy fishing activity, such as Barcelos, Presidente Figueiredo, Itacoatiara, Borba, and Careiro, should receive attention from management and oversight bodies. The increasing number of anglers could potentially negatively impact fish stocks in these areas. Emphasizing the importance of studying the carrying capacity of the main tributaries used for sport fishing is crucial for ensuring long-term environmental conservation and sustainable development. Such approach can support future proposals for the sustainable management of fisheries through the zoning of fishing areas in the state of Amazonas.

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