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The effects of river impoundment on artisanal fishers in the Middle Tocantins River, Brazil

Os efeitos do represamento fluvial sobre pescadores artesanais no Médio Rio Tocantins, Brasil

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Abstract: Aim: The present study investigated the social impacts caused by the construction of a large hydropower dam (Lajeado Dam) on artisanal fishers in the Middle Tocantins River, evaluating how the impoundment affected fishing techniques (locations, transport and gears), operation (income, effort and costs), and fisher's well-being. **Methods:** The study interviewed 30 artisanal fishers (Colony Z-04, Porto Nacional, TO) between August and October 2018 with the application of a structured questionnaire. **Results:** Results indicated that fishing is socially important as a source of income and occupation, carried out essentially by men with low levels of formal education. Fishers reported, however, significant changes in the fishery system after the impoundment of the Tocantins River. The main fishing area was maintained, but fishers abandoned some sites. There were significant changes in fishing equipment, with an increase in the use of aluminum boats and outboard engines, and a reduction in the use of various gears, replaced by the use of gillnets. Almost all fishers (96.6%) declared that fishing effort and the financial costs increased after damming. Many also reported an increase in financial income (70%), but part reported a decrease, no change or could not say. The majority reported that the impoundment damaged the fishing activity (80%) and their well-being (individual and their families; 83.3%); dissatisfaction with the profession also increased. **Conclusions:** Results indicated that the impoundment created by Lajeado Dam impacted several aspects of artisanal fisheries in the Middle Tocantins, with a wide perception of damage, which indicates that working conditions of fishers have declined. This information is relevant and can support fisheries management in the Tocantins River Basin, in order to balance societal demands with sustainability goals and fisher's needs.

Keywords: fish fauna; impact; fishery; perception; social.

Resumo: Objetivo: O presente estudo investigou os impactos sociais causados pela construção de uma grande barragem hidrelétrica (barragem de Lajeado) sobre os pescadores artesanais que atuam no Médio Rio Tocantins, avaliando como o represamento do rio afetou as técnicas de pesca (locais, transporte e petrechos), sua condução (geração de renda, esforço e custos) e o bem-estar dos pescadores. **Métodos:** O estudo entrevistou 30 pescadores artesanais (Colônia Z-04, Porto Nacional, TO) entre agosto e outubro de 2018 com a aplicação de um questionário estruturado. **Resultados:** Os resultados indicaram que a pesca tem grande relevância social como fonte de renda e geração de emprego, exercida essencialmente por homens com baixo nível de escolaridade. No entanto, os pescadores relataram

mudanças significativas na atividade pesqueira após o represamento do rio Tocantins. A principal área de pesca foi mantida, mas os pescadores abandonaram alguns locais. Houve mudança notável nos equipamentos de pesca, com aumento significativo no uso de barco de alumínio e motor, redução no uso de diversos petrechos, e aumento no emprego de malhadeiras. Quase todos os pescadores (96%) declararam aumento no tempo gasto com a pesca e no custo financeiro envolvido. A maioria também afirmou aumento da renda financeira (70%), embora parte tenha relatado diminuição, ausência de alteração ou não soube dizer. A grande maioria relatou que o represamento prejudicou a atividade pesqueira (80%) e seu bem estar (individual e de sua família; 83.3%); também houve aumento na insatisfação com a profissão. **Conclusões:** Os resultados indicaram que o represamento da usina de Lajeado impactou diversos componentes da pesca artesanal no Médio Tocantins, com ampla percepção de prejuízo, o que indica piora nas condições de trabalho dos pescadores. Essas informações são relevantes para o ordenamento e gestão pesqueira na bacia do Rio Tocantins, no intuito de equilibrar as demandas da sociedade com metas de sustentabilidade e necessidades dos pescadores.

Palavras-chave: ictiofauna; impacto; pesca; percepção; social.

1. Introduction

Artisanal fishing is one of the oldest activities in human history, which has emerged spontaneously in all drainages and ecosystems of the planet. This modality is usually conducted on a small scale, involving simple technology and exerting low fishing pressure, although it has a complex and diversified nature (Rousseau et al., 2019). It has been conducted mostly for subsistence, trade, or income generation, using multiple gears to catch a wide range of aquatic organisms, mainly fish. Commonly, it has traditional roots, transmitted over generations, promoting social and cultural engagement (Bené, 2006; Chiaravalloti & Dyble, 2018; Lasso & Morales-Betancourt, 2021). Currently, artisanal fishing is globally widespread, being highly relevant in underdeveloped or developing countries, where it provides food, income and opportunities for millions of families in Latin America, Africa and Asia (Funge-Smith, 2018). In Brazil, it is found in all major river drainages (e.g., Petrere Junior, 1989; Petrere Junior et al., 2002; Godinho & Godinho, 2003; Castro et al., 2008; Isaac et al., 2008; Mérona et al., 2010; Schork et al., 2012), benefited by the several ecosystem services provided by the Neotropical fish fauna (Pelicice et al., 2022).

The current degradation of South American rivers, however, has impacted fishing activities in different ways. The large-scale degradation of the environment and the consequent loss of fish diversity have impacted the quality and quantity of fishing resources (Alho et al., 2015; Reis et al., 2016; Pelicice et al., 2017; D'Avilla et al., 2021). The construction of hydropower plants, in particular, has been a major source of disturbances (Petrere Junior, 1996; Agostinho et al., 2007). Currently, hundreds of dams regulate most river systems in South America, especially in the southern and southeastern regions of Brazil (Agostinho et al., 2016), where artisanal and commercial fishing has experienced profound changes (Petrere Junior et al., 2002; Hoeinghaus et al., 2009; Novaes & Carvalho, 2013; Scarabotti et al., 2021). The decline of commercially important stocks, usually composed of large migratory fish, has forced artisanal fisheries to catch smaller fish that colonize reservoirs and degraded areas (Petrere Junior, 1996). This process has changed artisanal fishing in several ways, by affecting fishing yield, income, and the lifestyle of fishers (Agostinho et al., 2007).

Hydroelectric expansion has also advanced over the vast Amazon region (Winemiller et al., 2016; Latrubesse et al., 2021), impacting fish diversity and fishing systems (Castello et al., 2013; Alho et al., 2015; Cella-Ribeiro et al., 2017; Sant'Anna et al., 2020; Duponchelle et al., 2020). The Tocantins River Basin is the most affected by large and small hydroelectric dams, which regulate the main channel and several tributaries (Akama, 2017; Pelicice et al., 2021). In the Lower Tocantins, the Tucurui Dam induced significant changes to artisanal and commercial fisheries, which currently rely on non-migratory fish with lower commercial value (Ribeiro et al., 1995; Camargo & Petrere Junior, 2004; Mérona et al., 2010; Hallwass et al., 2013). In the Upper and Middle Tocantins, where hydroelectric development is more intense, artisanal fishing is less developed, although little is known about its basic aspects and how dams have affected them. The few exiting studies indicated changes in fish catches and yield (Gomes, 2007; Garavello et al., 2010; Foschiera & Pereira, 2014), although there are no monitoring or quantitative studies comparing scenarios before and after river regulation. It is well known, however, that dams promoted substantial changes to fish diversity (Agostinho et al., 2009; Araújo et al., 2013; Medeiros et al., 2014; Lima et al., 2016;

Perônico et al., 2020; Pereira et al., 2021), with obvious effects on fishing stocks, as reported by local fishers (Foschiera & Pereira, 2014). Yet, the impact of dams on artisanal fishers and fishing activities remains poorly understood.

In this context, the present study investigated how the construction of the Luís Eduardo Magalhães Hydropower Plant (also known as Lajeado Dam) affected artisanal fishers in the Middle Tocantins, based on interviews conducted with fishers in the area impacted by the impoundment. In particular, the study described basic characteristics of the fishers associated with Colony Z-04 (Porto Nacional, TO), and investigated how the impoundment affected multiple aspects of the artisanal fishing, such as sites, transport, gears, income, effort, costs, and fisher's well-being.

2. Material and Methods

2.1. Study area

The Tocantins-Araguaia River Basin drains approximately 760,000 km^2 of central/northern Brazil, with an average discharge of ca. 11,000 m^3/s (Ribeiro et al., 1995). The Tocantins River is considered the main channel of the basin, with a length of about 2,500 km. This river runs in the south-north direction towards the Marajó Island, near the confluence of the Amazon River with the Atlantic Ocean. Currently, its main channel is regulated by seven large hydroelectric dams, which created large impoundments and changed the natural flow regime (Akama, 2017; Pelicice et al., 2021). These dams are present throughout the basin, but most were built in the last fifteen years in the Upper and Middle sections of the basin.

The study area is under the influence of the Luís Eduardo Magalhães Hydroelectric Plant (Lajeado Dam), with an installed capacity of 902.5 MW, located in the Middle Tocantins (9º 45'26.90" S and 48º22'19.21" W). This dam is the 5th in the cascade of dams along the river, constructed between 1998 and 2002. It formed a large impounded (630 km^2 surface area, 150 km long, 8.8 m average depth, 24 days retention time) that flooded vast areas of savanna vegetation. The dam is equipped with a fish ladder (weir and pool type), but it was closed due to operational problems related to malfunctioning and potential impacts on migratory fish (Agostinho et al., 2011).

The investigation was conducted in the municipality of Porto Nacional, Tocantins State. Artisanal fishing in the Tocantins State has been permitted by law only recently (after the 2000s; Miranda et al., 2017), but fishing activities (i.e., artisanal, commercial and recreational) have been conducted previously on a clandestine basis. The Colony Z-04, located in Porto Nacional, is an association created in 2004 with the aim of organizing fishing activities and providing support to artisanal fishers. The number of associated members has changed over the years. Originally, it had 300 members, but this number reduced significantly in the following years, ca. 50 in 2014 (Foschiera & Pereira, 2014). During the conduction of this study (2018) the Colony had 115 members, but currently (May 2023) it has 63.

2.2. Data collection

We conducted systematic interviews with fishers associated with the Colony Z-04, with the application of a structured questionnaire (Table 1). The interviews took place between August and October 2018. This research was supported by the president of the Colony, who provided registration data of all members, including full name and contact (residence and telephone). The selection criterion considered the experience of fishers in the region, selecting only those with a long history of fishing activities (more than 20 years), sufficient to cover periods before and after the construction of Lajeado Dam.

To approach and interview the fishers, this research followed methodology widely applied in ethnobiological and social studies concerning ethical issues (e.g., Cetra & Petrere Junior, 2001; Silvano et al., 2006; Hallwass et al., 2013; Catelani et al., 2021), and the research protocol followed the main guidelines of the Declaration of Helsinki for research with humans. Each fisher was invited separately to participate in the research, and the decision to collaborate was voluntary. The fishers who agreed to participate signed a free and informed consent term. We first explained the objectives of the research and its relevance for fisheries management. We also clarified that participants would remain anonymous, and that data collected would be used to support scientific investigations and knowledge dissemination. The interview was conducted always by the same investigator (M.A.A.S.), and occurred individually at the home of each fisher.

The structured questionnaire contained 3 sections: A) Profile; B) Fishing activity; C) Dam effects (Table 1). Section A included questions about basic aspects of artisanal fishers: gender, birthplace, residence, age, and level of education.

Table 1. Structured questionary used to interview artisanal fishers.

Questions	Answers
PART A. Fisher's profile	
Age:	
Gender:	() man () woman
Birthplace:	
Residence (city):	
Formal education:	() never studied
	() primary () incomplete () complete
	() high school () incomplete () complete
	() college () incomplete () complete
	() postgraduate
PART B. Fishing activity	
Is fishing your main activity?	() yes () no
How many years have you been in the fishing activity?	
Have you fished before the construction of Lajeado Dam?	() no () yes - How many years have you fished?
Have you fished after the construction of Lajeado Dam?	() no () yes - How many years have you fished?
Have your parents worked as fishers?	() yes () no
Have your descendants worked as fishers?	() yes () no
PART C. Dam effects	
Main fishing sites:	Before: () Dam to Porto Nacional, () Porto Nacional to Brejinho de Nazaré, () Upstream Brejinho de Nazaré, () another site:
	After: () Dam to Porto Nacional, () Porto Nacional to Brejinho de Nazaré, () Upstream Brejinho de Nazaré, () another site:
Fishing gears?	Before: After:
Transport used for fishing?	Before: () wooden canoe, () aluminum boat, () row, () outboard engine, () no transport, () other:
	After: () wooden canoe, () aluminum boat, () row, () outboard engine, () no transport, () other:
Fishing days per month? (estimate)	Before: After: () do not know
Group working?	Before: () no () yes – how many:
	After: () no () yes – how many:
	() do not know
Family engagement?	Before: () no () yes – how:
	After: () no () yes – how:
	() do not know
Time spent with fishing/month?	() increase after dam construction, () decreased after dam, () no change, () do not know
Financial costs with fishing?	() increase after dam construction, () decreased after dam, () no change, () do not know
Income obtained with fishing?	() increase after dam construction, () decreased after dam, () no change, () do not know
How do you feel about your profession?	Before: () satisfied, () dissatisfied, () would abandon if had an alternative
	After: () satisfied, () dissatisfied, () would abandon if had an alternative
What the construction of Lajeado Dam has caused to the fishing activity?	Damage: () weak () moderate () strong
	Benefit: () weak () moderate () strong
	No effect ()
What the construction of Lajeado Dam has caused to your well-being and your family?	Damage: () weak () moderate () strong
	Benefit: () weak () moderate () strong
	No effect ()

Section B included questions about aspects of the fishing activity: the importance of fishing as a source of income, the experience of fishers, and hereditary aspects. Section C assessed the interaction between the fishing activity and the impoundment: fishing sites, gears, transport, effort (fishing days/

month), group working, family engagement, level of satisfaction with the profession, costs, income, and the perception of how the dam affected fishing activities and fisher's well-being (individual and their family).

2.3. Data analysis

To characterize fisher's profile, we calculated the percentage of respondents regarding gender, birthplace, residence, and level of education; we also calculated their average age (minimum and maximum). To characterize fishing activities, we calculated the percentage of respondents who have artisanal fishing as their main activity, the average (minimum and maximum) number of years involved in artisanal fishing (overall, before and after the impoundment), and the percentage of respondents whose parents were fishers and whose descendants are fishers.

To assess the effects of the dam on artisanal fishers, we calculated the percentage of responses in relation to fishing sites, gears, transport, group working, and family engagement before and after the impoundment. Statistical differences were investigated for sites, gears, and transport between periods, using Chi^2 tests in the software Past 2.17 (Hammer et al., 2001). We also investigated the perception of artisanal fishers regarding changes in fishing effort (time), costs and income, calculating the percentage of respondents who indicated increase, decrease or no change. To assess the perception of fishers about the effects of the dam on fishing activities and their well-being, we calculated the percentage of respondents who felt damaged, benefited or indifferent about the changes, considering a scale of effects: weak, moderate and strong. Finally, we assessed their level of satisfaction with their profession by calculating the percentage of (i) respondents in each satisfaction level (low, partial or high), and (ii) respondents that manifested the desire to abandon this profession.

3. Results

We interviewed 30 fishers in this study, 28 men and two women. Table 2 provides basic information about the fishers and their experience with artisanal fishing. All respondents reside in Porto Nacional, Tocantins, and most declared their birthplace as Tocantins State (27 individuals, 90%). Most fishers reported incomplete primary education (27 individuals, 90%), and almost all (29 individuals, 96.7%) declared artisanal fishing as their main activity. Twenty-two (73.3%) declared that their parents were fishers, while 17 (56.7%) reported that their descendants are fishers.

They were 53 years-old on average, with experience in artisanal fishing of 41 years (23 years before, and 17 years after the impoundment). Regarding fishing effort (average days/month), they reported 14 days before and 17 days after the impoundment. Most fishers work in group (two or more people), and involve family members to aid in activities like fishing, processing, and selling. Fish is usually sold in urban areas (trade fairs) or at their homes.

Fishers reported changes in fishing sites, transport and gears after the impoundment (Figure 1), and we detected significant statistical differences in proportions between periods (Sites: $Chi^2 = 20.73$, $p < 0.0001$; Transport: $Chi^2 = 93.71$, $p < 0.0001$; Gears: $Chi^2 = 81.07$, $p < 0.0001$). In both periods, the main fishing site was the section between Porto Nacional and Brejinho de Nazaré (Figure 1A), located in the upper stretch of the impoundment. However, fishers abandoned

Table 2. Characteristics of artisanal fishers in the area affected by Lajeado Dam, Middle Tocantins River, before and after the impoundment. Values shown are percentages or averages (minimum – maximum).

Variables	Overall	Period	
		Before	After
Man	93.3%		
Woman	6.7%		
Age	53 (29 – 77)		
Years of experience	41 (21 – 67)	23 (4 – 50)	17 (9 – 17)
Fishing effort (days/month)		14 (2 – 30)	17 (4 – 30)
Fishing as a main activity	96.7%		
Parent as fishers	73.3%		
Descendants as fishers	56.7%		
Group working		70%	76.7%
Family engagement		63.3%	60%

some sites after dam construction, including the downstream stretch between Porto Nacional and the dam (inner areas of the impoundment), rivers located in areas upstream (e.g., Areias, Manuel Alves, Santa Tereza, São Valério), and other places (e.g., Água Suja and Balsas rivers, and the Araguaia Basin). We also detected changes in fishing transport (Figure 1B), with a significant increase in the use of aluminum boats and outboard engines. A similar trend was observed for fishing gears (Figure 1C), with a reduction in the use of various gears after dam construction, such as pinda (a type of float), hand line, longline, cast net, rods and floats. On the other hand, the use of gill nets increased and new gears appeared, such as cast reels and artificial baits.

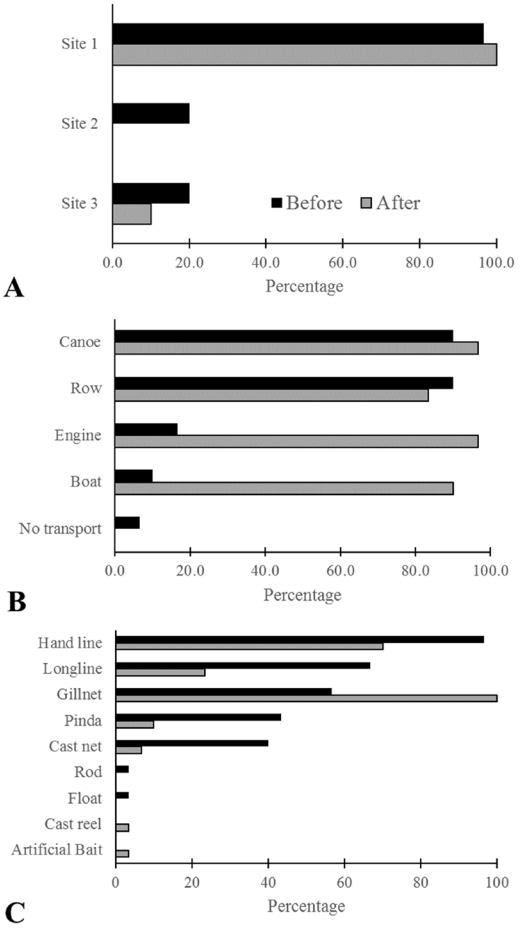

Figure 1. Fishing sites (A), transport (B), and gears (C) used by artisanal fishers before and after the construction of Lajeado Dam, Middle Tocantins, as reported by interviewed fishers (n = 30). Site 1 = section between Porto Nacional and Brejinho de Nazaré (upper stretch of the impoundment); Site 2 = other sites, which include several rivers in the region; Site 3 = section between Porto Nacional and the dam (impounded area).

Fishers reported changes in effort, costs and income associated with fisheries after the construction of Lajeado Dam (Figure 2). Almost all fishers (96.6%) reported that fishing effort (time spent with fishing/month) and financial costs increased after dam construction. Most fishers also declared that income increased (70%), but some (30%) reported a decrease, absence of change, or could not inform about this question.

Almost all fishers (80%) reported that the impoundment damaged the fishing activity, while the rest indicated a perception of benefits (20%) (Figure 3A). Similarly, the majority stated that the impoundment damaged (83.3%) their well-being, while the rest perceived benefits (10%) or no change (6.7%) (Figure 3B). Almost all respondents (96.6%) felt satisfied with the profession before the construction of the dam (Figure 4), and no fisher declared intention to leave the activity if they had alternatives. Dissatisfaction increased after the impoundment (Figure 4), and 26.6% declared intention to leave the profession.

4. Discussion

This study examined how the construction of Lajeado Dam (Middle Tocantins River) affected artisanal fishers in the area impacted by the impoundment. According to the fishers, the impoundment changed several aspects of the fishing activity (i.e., sites, transport, gears, effort, cost, and income), and affected their well-being. In general, there was a wide perception of damage and an increase in dissatisfaction with the profession, indicating that, even with the higher income reported, working conditions have declined.

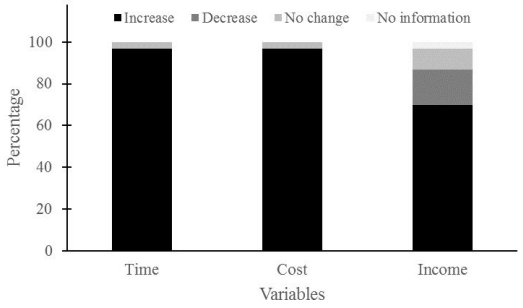

Figure 2. Changes in aspects of artisanal fisheries after the construction of Lajeado Dam, Middle Tocantins, as reported by interviewed fishers (n = 30). The figure shows the perception of fishers (% of respondents) regarding changes in fishing effort (time spent with fishing/month), costs, and income associated with fisheries, according to the scale: increase, decrease, no change, or not informed.

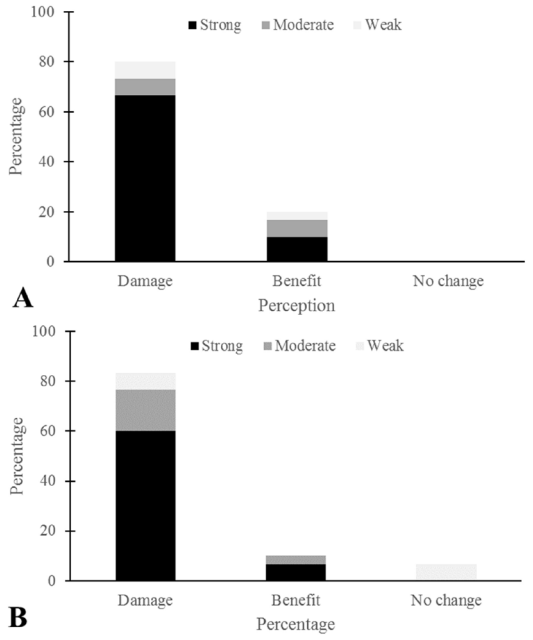

Figure 3. Fisher's perception about how Lajeado Dam impacted traditional fishing (A) and their well-being (individual and their families) (B), as reported by interviewed fishers (n = 30). Impact perception was assigned as Damaged, Benefited or No change, according to the scale: strong, moderate, and weak.

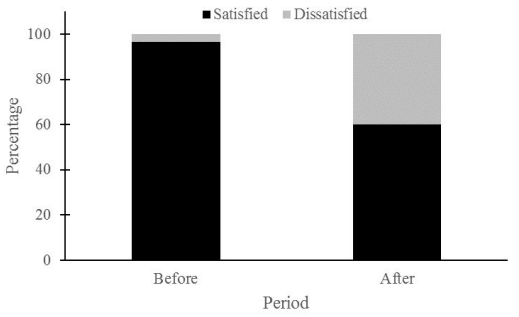

Figure 4. Professional satisfaction before and after the construction of Lajeado Dam, Tocantins River, as reported by interviewed fishers (n = 30).

These results are in line with patterns observed downstream from Lajeado Dam (Gomes, 2007; Alho et al., 2015), and follow trends observed in other drainages (Agostinho et al., 2007; Sant'Anna et al., 2020; D'Avilla et al., 2021), where the construction of hydroelectric dams induced significant changes to artisanal fisheries, causing substantial losses to fishers. Results also support fish fauna studies conducted in the Tocantins basin, which have shown drastic changes in fish richness, abundance and composition (Araújo et al., 2013; Perônico et al., 2020; Pereira et al., 2021) – which translate into changes in the quality of fishing resources.

According to our study, artisanal fishing is a relevant socioeconomic activity in the impounded area of Lajeado Dam, carried out mostly by men (from the Tocantins State) with a low level of formal education, a common pattern in Brazilian drainages (Petrere Junior, 1989; Camargo & Petrere Junior, 2001; Maruyama et al., 2009; Alencar & Maia, 2011; Reis et al., 2022). In Brazil, inland artisanal fisheries have been an undervalued profession (Godinho & Godinho, 2003; Agostinho et al., 2007), which offer limited social and economic opportunities for individual development. As a result, the activity has been conducted by people with low levels of formal education, extensively excluded from the formal market. However, artisanal fisheries have played important socioeconomic roles by offering income and subsistence opportunities for millions of families around the world (Oliveira Junior et al., 2016; Funge-Smith, 2018). Fishing activities in the Upper and Middle Tocantins are poorly known, especially within the state of Tocantins, as fishing was not regulated until recently (after the 2000s; Miranda et al., 2017). There is no official monitoring in this region, with no information about catch composition and yield. It is likely that artisanal fishing in the region has a lower economic value if compared to the Lower Tocantins and the Araguaia Basin, where commercial, recreational and artisanal fisheries are relevant (Mérona et al., 2010; Prysthon et al., 2022). However, fisheries in the Upper and Middle Tocantins are essentially artisanal, and they seem to have a strong social impact (Gomes, 2007; Garavello et al., 2010; Foschiera & Pereira, 2014). Our results confirmed this scenario, as almost all fishers had fishing as a main occupation, with a long history in the activity (41 years on average), encompassing moments before and after the construction of the dam. Indeed, Foschiera & Pereira (2014) reported that fishing has always played a role in the livelihood of these fishers, assuming a prominent economic role after its formal regulation. It should be noted that artisanal fishing usually have strong traditional roots, transmitted over generations, although our results showed that the engagement of fisher's descendants is decreasing. This is a general trend in Brazil (e.g., Zappes et al., 2016; Reis et al., 2022), probably linked to the decline of fishing resources, the low income associated with artisanal fishing, and limited social opportunities.

Artisanal fishers reported significant changes in the fishing activity after the construction of Lajeado Dam. The main fishing area was maintained (i.e., the upper section of the impoundment), but they abandoned several sites located upstream and elsewhere. It indicates that, after river regulation, fishing effort concentrated substantially in impounded sites close to Porto Nacional, which may elicit disputes and conflicts over fishing areas and resources. Similar patterns have been observed in other Brazilian drainages, where fishers have adapted to work in reservoirs (Okada et al., 2005; Agostinho et al., 2007; D'Avilla et al., 2021), changing fishing sites, target species, and techniques. In river systems, artisanal fisheries tend to use a wide variety of methods depending on the season, target species and the environment (Cetra & Petrere Junior, 2001; Hallwass & Silvano, 2016; Sant'Anna et al., 2020); it was verified in our study area before the construction of Lajeado Dam, when fishers used different gears and transport. After the impoundment, we recorded a reduction in the use of several gears, such as pindas, cast nets and longlines, equipment used to capture fish moving or migrating along the river channel. Although cast nets can be used in reservoirs to catch some specific fish (*e.g.*, tilapias; Minte-Vera & Petrere Junior, 2000; Novaes & Carvalho, 2013), its use in Lajeado may have been limited by fishing legislation and the presence of submerged structures (branches, trunks, macrophytes). It is worth noting the increased use of gillnets and motorized boats, virtually absent before river regulation, but currently used by almost all fishers. Gillnets have been widely used in reservoirs (Okada et al., 2005; Mérona et al., 2010; Novaes & Carvalho, 2013), as they are effective in lentic environments and capture a variety of fish species. The use of motorized boats is probably associated with the need for greater displacements across the impoundment, although the use of such equipment increases fishing costs (Ceregato & Petrere Junior, 2003).

Most fishers declared that income increased after the impoundment, a fact probably related to the regulation of the fishing activity during the 2000s (Miranda et al., 2017), which coincided with the construction of Lajeado Dam. Before that, fishing was clandestine and essentially for subsistence. Economic revenues emerged and consolidated after the impoundment (Foschiera & Pereira, 2014), when the profession was formally recognized and fishers were allowed to market fish. It should be noted that fisheries usually generate higher economic profits in river environments if compared to impoundments (Ceregato & Petrere Junior, 2003; Agostinho et al., 2016), a likely effect of the greater diversity of fishing resources, and the presence of target species with higher economic value (migratory fish) and large fish stocks. In the area impounded by Lajeado Dam, fishers reported substantial changes in the fishing resource (Foschiera & Pereira, 2014), with the decline or loss of highly valued stocks (Santos, M.A. unpublished data); moreover, about 1/3 of the interviewed fishers declared that income declined or remained the same. The increase in income must also be pondered with the costs associated with fishing; practically all fishers reported increases in the time dedicated to fishing and in the financial cost to maintain it, aspects probably linked to the professionalization of the activity, the acquisition of new equipment (e.g., gill nets, aluminum boat, outboard engine), and changes in fish diversity (e.g., Araújo et al., 2013; Perônico et al., 2020). As a result, the higher income was accompanied by greater work effort and costs, which may not result in improvements in the living conditions of artisanal fishers.

In fact, there was a widespread perception that the impoundment affected negatively the fishing activity, as most fishers stated that the impoundment damaged artisanal fishing and fisher's well-being. River damming causes large-scale environmental impacts, promoting profound changes in fish diversity and fishing resources (Agostinho et al., 2016). Fish biomass and yield usually increase in the first years of the impoundment, but they decline sharply in the following years (Petrere Junior, 1996; Agostinho et al., 1999; Monaghan et al., 2020). Impacts affect mainly migratory fishes, which have high commercial value and are appreciated by artisanal and commercial fisheries (Junk et al., 2007; Castello et al., 2013; D'Avilla et al., 2021; Duponchelle et al., 2020) – but decline dramatically in impounded areas (Loures & Pompeu, 2018; Pelicice et al., 2018; Smith et al., 2019). Fish communities in reservoirs are composed mainly of species with low commercial value (Agostinho et al., 2007; Hoeinghaus et al., 2009), making fisheries less productive and profitable. Moreover, the impoundment brings other inconveniences to artisanal fishers, such as the loss of leisure sites (seasonal beaches), the excessive growth of aquatic plants that impair navigation and accessibility, the presence of submerged logs, the proliferation of nuisance animals (e.g., piranhas, stingrays, mosquitoes), algal blooms, among others –

phenomena commonly observed in Brazilian reservoirs, including Lajeado (Petrere Junior, 1996; Agostinho et al., 2007; Mérona et al., 2010; Noleto et al., 2019). This new scenario should explain the increase in dissatisfaction with the profession, as reported by fishers. It is worth noting that almost all were satisfied before the construction of Lajeado Dam, but this percentage declined after river regulation, and some fishers (ca. 27%) manifested the desire to leave the profession.

In the absence of fishing monitoring and quantitative data on catches and yield, studies that assess the perception of the involved agents (i.e., fishers) represent an important approach in generating quali-quantitative data to understand fishery dynamics and socioeconomic aspects in scenarios of environmental change (Hallwass et al., 2013). This information is relevant and can support fisheries management in rivers and reservoirs, in order to balance societal demands with sustainability goals and fisher's needs. It is very important that public policies include the knowledge and needs of fishers in fishery management plans and regulations, encouraging participatory management, which has generated good experiences elsewhere (Maccord et al., 2007; Almeida et al., 2009; Batista & Lima, 2010). Artisanal fishers represent an economically and politically weak segment, usually ignored by authorities, but highly vulnerable to development policies (Bené, 2003). For example, the expansion of aquaculture in the Tocantins State has elicited conflicts among stakeholders, and some artisanal fishers have abandoned the profession in order to engage in aquaculture production; however, this process is very complex, with a high risk of failure (Agostinho et al., 2007). Similarly, policies to implement non-take fishing regimes (i.e., catch and release, *cota zero*), stimulated by tourism and sport fishing, have high potential to impact artisanal fishers if regulations restrict catch and sales.

In conclusion, our study collected evidence that the impoundment of Lajeado Dam, in the Middle Tocantins River, changed several aspects of artisanal fishing and affected the well-being of fishers and their families. Artisanal fishers in the Upper and Middle Tocantins face unfavorable conditions, which include impacts from dams, expansion of aquaculture with exotic species, large-scale deforestation, silting, in addition to conflicts with other stakeholders (Pelicice et al., 2021). The weak political power of this class, especially in face of hydropower development, has been a rule in the Amazon Basin (Doria et al., 2018). This scenario is progressing fast, and reveals the need for better policies that explicitly consider the needs of artisanal fishers.

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References

Agostinho, A.A., Gomes, L.C., & Pelicice, F.M., 2007. Ecologia e manejo de recurso pesqueiro em reservatórios do Brasil. Maringa: Eduem.

Agostinho, A.A., Gomes, L.C., Santos, N.L., Ortega, J.C.G., & Pelicice, F.M., 2016. Fish assemblages in Neotropical reservoirs: colonization patterns, impacts and management. Fish. Res. 173, 26-36. http://dx.doi.org/10.1016/j.fishres.2015.04.006.

Agostinho, A.A., Miranda, L.E., Bini, L.M., Gomes, L.C., Thomaz, S.M., & Suzuki, H.I., 1999. Patterns of colonization in Neotropical reservoirs, and prognoses on aging. In: Tundisi, J.G. & Straskraba, M., eds. Theoretical reservoir ecology and its applications. Leiden: Backhuys Publishers, 227–265.

Agostinho, C.S., Pelicice, F.M., & Marques, E.E., 2009. Reservatório de Peixe Angical: bases ecológicas para o manejo da ictiofauna. São Carlos: RiMa Editora.

Agostinho, C.S., Pelicice, F.M., Marques, E.E., Soares, A.B., & Almeida, D.A.A., 2011. All that goes up must come down? Absence of downstream passage through a fish ladder in a large Amazonian river. Hydrobiologia 675(1), 1-12. http://dx.doi.org/10.1007/s10750-011-0787-0.

Akama, A., 2017. Impacts of the hydroelectric power generation over the fish fauna of the Tocantins river, Brazil: marabá dam, the final blow. Oecol. Aust. 21(02), e8. http://dx.doi.org/10.4257/oeco.2017.2103.01.

Alencar, C.A.G. & Maia, L.P., 2011. Perfil socioeconômico dos pescadores Brasileiros. Arq. Ciên. Mar, 44(3), 12-19.

Alho, C.J.R., Reis, R.E., & Aquino, P.P.V., 2015. Amazon freshwater habitats experiencing envinomental and socioeconomic threats affecting subsistence fisheries.

Ambio 44(5), 412-425. PMid:25572836. http://dx.doi.org/10.1007/s13280-014-0610-z.

Almeida, O.T., Lorenzen, K., & McGrath, D.G., 2009. Fishing agreements in the lower Amazon: for gain and restraint. Fish. Manag. Ecol. 16(1), 61-67. http://dx.doi.org/10.1111/j.1365-2400.2008.00647.x.

Araújo, E.S., Marques, E.E., Freitas, I.S., Neuberger, A.L., Fernandes, R., & Pelicice, F.M., 2013. Changes in distance decay relationships after river regulation: similarity among fish assemblages in a large Amazonian river. Ecol. Freshwat. Fish 22(4), 543-552. http://dx.doi.org/10.1111/eff.12054.

Batista, V.S., & Lima, L.G., 2010. In search of traditional bio-ecological knowledge useful for fisheries co-management: the case of jaraqui *Semaprochilodus* spp. (Characiformes, Prochilodontidae) in Central Amazon, Brazil. J. Ethnobiol. Ethnomed. 6(1), 15. PMid:20525294. http://dx.doi.org/10.1186/1746-4269-6-15.

Bené, C., 2003. When fishery rhymes with poverty – a first step beyond the old paradigm on poverty in small-scale fisheries. World Dev. 31(6), 949-975. http://dx.doi.org/10.1016/S0305-750X(03)00045-7.

Bené, C., 2006. Small-scale fisheries: assessing their contribution to rural livelihoods in developing countries. Rome: FAO, FAO Fisheries Circular, No. 1008).

Camargo, S.A.F., & Petrere Junior, M., 2001. Social and financial aspects of the artisanal fisheries of middle São Francisco River, Minas Gerais, Brazil. Fish. Manag. Ecol. 8(2), 163-171. http://dx.doi.org/10.1046/j.1365-2400.2001.00246.x.

Camargo, S.A.F., & Petrere Junior, M., 2004. Análise de risco aplicada ao manejo precaucionário das pescarias artesanais na região do Reservatório da UHE-Tucuruí (Pará, Brasil). Acta Amazon. 34(3), 473-485. http://dx.doi.org/10.1590/S0044-59672004000300013.

Castello, L., McGrath, G.D., Hess, L.L., Coe, T.M., Lefebvre, A.P., Petry, P., Macedo, N.M., Renó, F.V., & Arantes, C.C., 2013. The vulnerability of Amazon freshwater ecosystems. Conserv. Lett. 6(4), 217-229. http://dx.doi.org/10.1111/conl.12008.

Castro, P.M.G., Maruyama, L.S., & Paiva, P., 2008. Pesca artesanal no médio e baixo rio Tietê (São Paulo, Brasil): pontos de desembarque e estimativa de número de pescadores. Bioikos (Campinas) 22, 15-27.

Catelani, P.A., Petry, A.C., Pelicice, F.M., & Silvano, R.A.M., 2021. Fishers' knowledge on the ecology, impacts and benefits of the non-native peacock bass *Cichla kelberi* in a coastal river in southeastern Brazil. Ethnobiol. Conserv. 10, 4.

Cella-Ribeiro, A., Doria, C.R.C., Dutka-Gianelli, J., Alves, H., & Torrente-Vilara, G., 2017. Temporal fish community responses to two cascade run-of- river dams in the Madeira River, Amazon basin. Ecohydrology 10(8), e1889. http://dx.doi.org/10.1002/eco.1889.

Ceregato, S.A., & Petrere Junior, M., 2003. Financial comparisons of the artisanal fisheries in Urubupungá complex in the middle Paraná river (Brazil). Brazil. J. Biol. 63(4), 673-682. PMid:15029378. http://dx.doi.org/10.1590/S1519-69842003000400014.

Cetra, M., & Petrere Junior, M., 2001. Small-scale fisheries in the middle River Tocantins, Imperatriz (MA), Brazil. Fish. Manag. Ecol. 8(2), 153-162. http://dx.doi.org/10.1046/j.1365-2400.2001.00233.x.

Chiaravalloti, R.M., & Dyble, M., 2018. Limited open access in socioecological systems: how do communities deal with environmental unpredictability? Conserv. Lett. 12, e12616. https://doi.org/10.1111/conl.12616.

D'avilla, T., Costa-Neto, E.M., & Brito, M.F.G., 2021. Impacts on fisheries assessed by local ecological knowledge in a reservoir cascade in the lower São Francisco River, northeastern Brazil. Neotrop. Ichthyol. 19(3), e200156. http://dx.doi.org/10.1590/1982-0224-2020-0156.

Doria, C.R.C., Athayde, S., Marques, E.E., Lima, M.A.L., Dutka-Gianelli, J., Ruffino, M.L., Kaplan, D., Freitas, C.E.C., & Isaac, V.N., 2018. The invisibility of fisheries in the process of hydropower development across the Amazon. Ambio 47(4), 453-465. PMid:29210012.

Duponchelle, F., Isaac, V.J., Doria, C.R.C., Damme, P.A.V., Herrera-R, G.A., Anderson, E.P., Cruz, R.E.A., Hauser, M., Hermann, T.W., Agudelo, E., Bonilla-Castilho, C., Barthem, R., Freitas, C.E.C., García-Dávila, C., Garcia-Vasquez, A., Renno, J.F., & Castello, L., 2020. Conservation of migratory fishes in the Amazon basin. Aquat. Conserv. 31(5), 1087-1105. http://dx.doi.org/10.1002/aqc.3550.

Foschiera, A.A., & Pereira, A.D., 2014. Pescadores do Rio Tocantins: perfil socioeconômico dos integrantes da colônia de pescadores de Porto Nacional (TO). Interface (Maynooth) 7, 93-105. Retrieved in 2023, February 9, from https://sistemas.uft.edu.br/periodicos/index.php/interface/article/view/696

Funge-Smith, S.J. 2018. Review of the state of world fishery resources: inland fisheries. Rome: FAO, Fisheries and Aquaculture Circular, No. C942.

Garavello, J.C., Garavello, J.P., & Oliveira, A.K., 2010. Ichthyofauna, fish supply and fishermen activities on the mid-Tocantins River, Maranhão State, Brazil. Braz. J. Biol. 70(3), 575-585. PMid:20730344. http://dx.doi.org/10.1590/S1519-69842010000300014.

Godinho, H.P., & Godinho, A.L., 2003. Águas, peixes e pescadores do São Francisco das Minas Gerais. Belo Horizonte: PUC Minas.

Gomes, K.D. 2007. Caracterização socioeconômica da pesca e percepção dos pescadores do rio Tocantins sobre as mudanças ambientais imediatamente

a jusante da barragem da UHE Lajeado – TO [Dissertação de mestrado em Xxxxx]. Palmas: Universidade Federal do Tocantins.

Hallwass, G., & Silvano, R.A.M., 2016. Patterns of selectiveness in the Amazonian freshwater fisheries: implications for management. J. Environ. Plann. Manage. 59(9), 1537-1559. http://dx.doi.org/10.1080/09640568.2015.1081587.

Hallwass, G., Lopes, P.F., Juras, A.A., & Silvano, R.A.M., 2013. Fishers' knowledge identifies environmental changes and fish abundance trends in impounded tropical rivers. Ecol. Appl. 23(2), 392-407. PMid:23634590. http://dx.doi.org/10.1890/12-0429.1.

Hammer, O., Harper, D.A.T., & Ryan, P.D., 2001. Past: paleontologia Statistics software package for education and data analysis. Palaeontol. Electronica 4(1), 1-9.

Hoeinghaus, D.J., Agostinho, A.A., Gomes, L.C., Pelicice, F.M., Okada, E.K., Latini, J.D., Kashiwaqui, E.A.L., & Winemiller, K.O., 2009. Effects of river impoundment on ecosystem services of large tropical rivers: embodied energy and market value of artisanal fisheries. Conserv. Biol. 23(5), 1222-1231. PMid:19459891. http://dx.doi.org/10.1111/j.1523-1739.2009.01248.x.

Isaac, V.J., Silva, C.O., & Ruffino, M.L., 2008. The artisanal fishery fleet of lower Amazon. Fish. Manag. Ecol. 15(3), 179-187. http://dx.doi.org/10.1111/j.1365-2400.2008.00599.x.

Junk, W.J., Soares, M.G.M., & Bayley, P.B., 2007. Freshwater fishes of the Amazon River basin: their biodiversity, fisheries, and habitats. Aquat. Ecosyst. Health Manage. 10(2), 153-173. http://dx.doi.org/10.1080/14634980701351023.

Lasso, C.A., & Morales-Betancourt, M.A., eds., 2021. La caza y pesca de subsistencia en el norte de Suramérica. Parte I: Colombia, Venezuela y Guyana. Bogotá: Instituto de Investigación de Recursos Biológicos Alexander von Humboldt, Serie Editorial Fauna Silvestre Neotropical.

Latrubesse, E.M., d'Horta, F.M., Ribas, C.C., Wittmann, F., Zuanon, J., Park, E., Dunne, T., Arima, E.Y., & Baker, P.A., 2021. Vulnerability of the biota in riverine and seasonally flooded habitats to damming of Amazonian rivers. Aquat. Conserv. 31(5), 1136-1149. http://dx.doi.org/10.1002/aqc.3424.

Lima, A.C., Agostinho, C.S., Sayanda, D., Pelicice, F.M., Soares, A.M.V.M., & Monaghan, K.A., 2016. The rise and fall of fish diversity in a neotropical river after impoundment. Hydrobiology 763(1), 207-221. http://dx.doi.org/10.1007/s10750-015-2377-z.

Loures, R.C., & Pompeu, P.S., 2018. Long-term study of reservoir cascade in south-eastern Brazil reveals spatio-temporal gradient in fish assemblages. Mar. Freshw. Res. 69(12), 1983-1994. http://dx.doi.org/10.1071/MF18109.

Maccord, P.F.L., Silvano, R.A.M., Ramires, M.S., Clauzet, M., & Begossi, A., 2007. Dynamics of artisanal fisheries in two Brazilian Amazonian reserves: implications to co-management. Hydrobiologia 583(1), 365-376. http://dx.doi.org/10.1007/s10750-006-0486-4.

Maruyama, L.S., Castro, P.M.G., & Paiva, P., 2009. Pesca artesanal no médio e baixo Tietê, São Paulo, Brasil: aspectos estruturais e socioeconômicos. Bol. Inst. Pesca 35(1), 61-81.

Medeiros, E.R., Pelicice, F.M., Agostinho, C.S., & Marques, E.E., 2014. Short-term changes in energy allocation by Hemiodontidae fish after the construction of a large reservoir (Lajeado Dam, Tocantins River). Neotrop. Ichthyol. 12(3), 649-658. http://dx.doi.org/10.1590/1982-0224-20130186.

Mérona, B., Juras, A.A., Santos, G.M., & Cintra, I.H.A., 2010. Os peixes e a pesca no baixo Rio Tocantins: vinte anos depois da UHE Tucuruí. Brasília: Eletronorte.

Minte-Vera, C.V., & Petrere Junior, M., 2000. Artisanal fisheries in urban reservoirs: a case study from Brazil (Billings Reservoir, São Paulo Metropolitan Region). Fish. Manag. Ecol. 7(6), 537-549. http://dx.doi.org/10.1046/j.1365-2400.2000.00218.x.

Miranda, E.B., Ferreira, D.T.A.M., & Marques, E.E., 2017. Dos conflitos à invisibilização da pesca profissional no estado do Tocantins. R. Gest. Sust. Ambient. 6(1), 272-298. http://dx.doi.org/10.19177/rgsa.v6e12017272-298.

Monaghan, K.A., Agostinho, C.S., Pelicice, F.M., & Soares, A.M.V.M., 2020. The impact of a hydroelectric dam on Neotropical fish communities: a spatio-temporal analysis of the Trophic Upsurge Hypothesis. Ecol. Freshwat. Fish 29(2), 384-397. http://dx.doi.org/10.1111/eff.12522.

Noleto, E.V., Barbosa, M.V.M., & Pelicice, F.M., 2019. Distribution of aquatic macrophytes along depth gradients in Lajeado Reservoir, Tocantins River, Brazil. Acta Limnol. Bras. 31, e6. http://dx.doi.org/10.1590/s2179-975x9317.

Novaes, J.L.C., & Carvalho, E.D., 2013. Analysis of artisanal fisheries in two reservoirs of the upper Paraná River basin (Southeastern Brazil). Neotrop. Ichthyol. 11(2), 403-412. http://dx.doi.org/10.1590/S1679-62252013005000002.

Okada, E.K., Agostinho, A.A., & Gomes, L.C., 2005. Spatial and temporal gradients in artisanal fisheries of a large Neotropical reservoir, the Itaipu Reservoir, Brazil. Can. J. Fish. Aquat. Sci. 62(3), 714-724. http://dx.doi.org/10.1139/f05-015.

Oliveira Junior, J.G.C., Silva, L.P.S., Malhado, A.C.M., Batista, V.S., Fabré, N.N., & Ladle, R.J., 2016. Artisanal fisheries research: a need for globalization?

PLoS One 11(3), e0150689. PMid:26942936. http://dx.doi.org/10.1371/journal.pone.0150689.

Pelicice, F.M., Agostinho, A.A., Akama, A., Andrade Filho, J.D., Azevedo-Santos, V.M., Barbosa, M.V.M., Bini, L.M., Brito, M.F.G., Candeiro, C.R.A., Caramaschi, E.P., Carvalho, P., Carvalho, R.A., Castello, L., Chagas, D.B., Chamon, C.C., Colli, G.R., Daga, V.S., Dias, M.S., Diniz Filho, J.A.F., Fearnside, P., Ferreira, W.M., Garcia, D.A.Z., Krolow, T.K., Kruger, R.F., Latrubesse, E.M., Lima Junior, D.P., Lolis, S.F., Lopes, F.A.C., Loyola, R.D., Magalhães, A.L.B., Malvasio, A., De Marco, P., Martins, P.R., Mazzoni, R., Nabout, J.C., Orsi, M.L., Padial, A.A., Pereira, H.R., Pereira, T.N.A., Perônico, P.B., Petrere, M., Pinheiro, R.T., Pires, E.F., Pompeu, P.S., Portelinha, T.C.G., Sano, E.E., Santos, V.L.M., Shimabukuro, P.H.F., Silva, I.G., Souza, L.B., Tejerina-Garro, F.L., Campos Telles, M.P., Teresa, F.B., Thomaz, S.M., Tonella, L.H., Vieira, L.C.G., Vitule, J.R.S., & Zuanon, J., 2021. Large-scale degradation of the Tocantins-Araguaia River Basin. Environ. Manage. 68(4), 445-452. PMid:34341867. http://dx.doi.org/10.1007/s00267-021-01513-7.

Pelicice, F.M., Agostinho, A.A., Azevedo-Santos, V.M., Bessa, E., Casatti, L., Garrone-Neto, D., Gomes, L.C., Pavanelli, C.S., Petry, A.C., Pompeu, P.S., Reis, R.E., Roque, F.O., Sabino, J., Sousa, L.M., Vilella, F.S., & Zuanon, J., 2022. Ecosystem services generated by Neotropical freshwater fishes. Hydrobiologia

Pelicice, F.M., Azevedo-Santos, V.M., Esguícero, A.L.H., Agostinho, A.A., & Arcifa, M.S., 2018. Fish diversity in the cascade of reservoirs along the Paranapanema River, southeast Brazil. Neotrop. Ichthyol. 16(2), e170150. http://dx.doi.org/10.1590/1982-0224-20170150.

Pelicice, F.M., Azevedo-Santos, V.M., Vitule, J.R.S., Orsi, M.L., Lima Junior, D.P., Magalhães, A.L.B., Pompeu, P.S., Petrere Junior, M., & Agostinho, A.A., 2017. Neotropical freshwater fishes imperilled by unsustainable policies. Fish Fish. 18(6), 1119-1133. http://dx.doi.org/10.1111/faf.12228.

Pereira, H.R., Gomes, L.F., Soares, P.T., Martins, P.R., Pelicice, F.M., Teresa, F.B., & Vieira, L.C.G., 2021. Long-term responses of fish diversity to river regulation: a multi-metric approach. Environ. Biol. Fishes 104(1), 71-84. http://dx.doi.org/10.1007/s10641-021-01056-0.

Perônico, P.B., Agostinho, C.S., Fernandes, R., & Pelicice, F.M., 2020. Community reassembly after river regulation: rapid loss of fish diversity and the emergence of a new state. Hydrobiologia 847(2), 519-533. http://dx.doi.org/10.1007/s10750-019-04117-9.

Petrere Junior, M., 1989. River fisheries in Brazil: a review. Regul. Rivers. Res. Manage. 4, 1-16.

Petrere Junior, M., 1996. Fisheries in large tropical reservoirs in South America. Lakes Reservoirs: Res. Manage. 2(1-2), 111-133. http://dx.doi.org/10.1111/j.1440-1770.1996.tb00054.x.

Petrere Junior, M., Agostinho, A.A., Okada, E.K., & Julio Junior, H.F., 2002. Review of the fisheries in the Brazilian portion of the Parana/Pantanal basin. In: Cowx, I.G., ed. Management and ecology of lake and reservoir fisheries. Osney Mead: Fishing New Books, 123-143. http://dx.doi.org/10.1002/9780470995679.ch11.

Prysthon, A., Ummus, M.E., Tardivo, T.F., Pedroza Filho, M.X., Chicrala, P.C.M.S., Kato, H.C.A., Dias, C.R.G. & Paz, L.R.S., 2022. A pesca artesanal no rio Araguaia, Tocantins, Brasil: aspectos tecnológicos e socioeconômicos. Rio de Janeiro: e-Publicar.

Reis, M.M.T., Ladislau, D.S., Ribeiro, M.W.S., Guimarães, C.C., Paiva, A.J.V., Mattos, D.C., Aride, P.H.R., & Oliveira, A.T., 2022. Socioeconomic aspects and profile of fishing according to fishers of commercial edible fish in the municipality of Barcelos, middle Negro River, Amazonas, Brazil. Braz. J. Biol. 82, e264210. PMid:36350939. http://dx.doi.org/10.1590/1519-6984.264210.

Reis, R.E., Albert, J.S., Di Dario, F., Mincarone, M.M., Petry, P., & Rocha, L.A., 2016. Fish biodiversity and conservation in South America. J. Fish Biol. 89(1), 12-47. PMid:27312713. http://dx.doi.org/10.1111/jfb.13016.

Ribeiro, B.L.C.M., Petrere Junior, M., & Juras, A.A., 1995. Ecological integrity and fisheries ecology of the Araguaia-Tocantins river basin, Brazil. Regul. Rivers. Res. Manage. 11, 325-350.

Rousseau, Y., Watson, R.A., Blanchard, J.L., & Fulton, E.A., 2019. Defining global artisanal fisheries. Mar. Policy 108, 103634. http://dx.doi.org/10.1016/j.marpol.2019.103634.

Sant'Anna, I.R.A., Rubens, E., Pinto, D.M., & Doria, C.R.C., 2020. Pescarias tradicionais da cachoeira do Teotônio submersas pela usinas em Rondônia. Rev. Programa Pos-Graduacao Hist. Univ. Fed. Amazonas 12, 229-248.

Scarabotti, P.A., Lucifora, L.O., Espínola, L.A., Rabuffetti, A.P., Liotta, J., Mantinian, J.E., Roux, J.P., Silva, N., Balboni, L., Vargas, F., Demonte, L.D., & Sánchez, S., 2021. Long-term trends of fishery landings and target fish populations in the lower La Plata basin. Neotrop. Ichthyol. 19(3), e210013. http://dx.doi.org/10.1590/1982-0224-2021-0013.

Schork, G., Hermes-Silva, S., Beux, L.F., Zaniboni-Filho, E., & Nuner, A.P.O., 2012. Diagnóstico da pesca artesanal na Usina Hidrelétrica de Machadinho, Alto rio Uruguai – Brasil. Bol. Inst. Pesca 38, 97-108. PMid:28562786.

Silvano, R.A.M., MacCord, P.F.L., Lima, R.V., & Begossi, A., 2006. When does this fish spawn? Fishermen's

local knowledge of migration and reproduction of Brazilian coastal fishes. Environ. Biol. Fishes 76(2-4), 371-386. http://dx.doi.org/10.1007/s10641-006-9043-2.

Smith, W.S., Stefani, M.S., Espíndola, E.L.G., & Rocha, O., 2019. Changes in fish species composition in the middle and lower Tietê River (São Paulo, Brazil) throughout the centuries, emphasizing rheophilic and introduced species. Acta Limnol. Bras. 30, e310.

Winemiller, K.O., Nam, S., Baird, I.G., Darwall, W., Lujan, N.K., Harrison, I., Stiassny, M.L.J., Silvano, R.A.M., Fitzgerald, D.B., Pelicice, F.M., Agostinho, A.A., Gomes, L.C., Albert, J.S., Baran, E., Petrere Junior, M., Zarfl, C., Mulligan, M., Sullivan, J.P., Arantes, C.C., Sousa, L.M., Koning, A.A., Hoeinghaus, D.J., Sabaj, M., Lundberg, J.G., Armbruster, J., Thieme, M.L., Petry, P., Zuanon, J., Vilara, G.T., Snoeks, J., Ou, C., Rainboth, W., Pavanelli, C.S., Akama, A., Van Soesbergen, A., & Sáenz, L., 2016. Balancing hydropower and biodiversity in the Amazon, Congo, and Mekong. Science 351(6269), 128-129. PMid:26744397. http://dx.doi.org/10.1126/science.aac7082.

Zappes, C.A., Oliveira, P.C., & Di Beneditto, A.P.M., 2016. Percepção de pescadores do norte fluminense sobre a viabilidade da pesca artesanal com a implantação de megaempreendimento portuário. Bol. Inst. Pesca 42(1), 73-88. http://dx.doi.org/10.20950/1678.2305.2016v42n1p73.

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