



## A sleeping giant: the historically neglected Brazilian fishing sector

José Belquior Gonçalves Neto<sup>a,\*</sup>, Felipe Augusto de Alencar Goyanna<sup>a</sup>, Caroline Vieira Feitosa<sup>a</sup>,  
Marcelo Oliveira Soares<sup>a,b,c</sup>

<sup>a</sup> Instituto de Ciências do Mar (LABOMAR), Universidade Federal do Ceará (UFC), Fortaleza, Brazil

<sup>b</sup> Dipartimento di Scienze e Tecnologie Biologiche e Ambientali (DISTEBA), Università del Salento, Lecce, Italy

<sup>c</sup> Institut de Ciència i Tecnologia Ambientals (ICTA), Universitat Autònoma de Barcelona (UAB), Carrer de les Columnes, Edifici Z, Cerdanyola del Vallés, Barcelona, Spain

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### ABSTRACT

Since the beginning of the decade of the oceans (2021–2030), many countries failed to even develop minimal fisheries management. In some countries, where legislation is appropriately applied to the logistics of marine fishing operations, some measures of containment and fisheries management are being implemented. However, other countries have no effective plans for the sustainable development of the sector. In this paper, we have compiled information on the historical discrepancies in fisheries management in the extensive Brazilian waters and used it to illustrate the institutional neglect of this important blue-economy sector. Since the 1930s, when the first management agencies were registered, fisheries management has been handled by at least 10 different federal agencies. This discontinuity has resulted in a country that is ignorant, overall, of the quantity fished, where fishing occurs, and the status of its fish stocks. The only available long-term fishing production data is held by small state departments or marine protected areas and does not come close to reflecting the total catch of the country, with its continental dimensions and its mix of artisanal and industrial fisheries. For this reason, the present work has compiled information on the years of neglect in the governance of the fishing sector. In addition, we suggest the creation of a pivotal management model, based on three main pillars, for sustainable fisheries development.

### 1. Introduction

For effective and, most importantly, sustainable fisheries development, it is essential to know the amount of fish extracted from the sea. Over the past few decades studies have indicated that specific fish stocks in the world have collapsed such as tuna, elasmobranchs (Fro-[mentin, 2009](#); [Pacoureaux et al., 2021](#)) and sardine fishing in the 90s in Brazil ([Freire, 2005](#); [Freire and Pauly, 2010](#)). However, recently, statistical bulletins show that stocks captured sustainably account for almost 60% of global catches ([FAO, 2020](#)). Though, these quantitative data do not include information from fisheries without active management and discards ([Duarte et al., 2020](#)).

Even with some well-managed stocks showing recovery in their exploitation levels ([FAO, 2020](#)), there are obstacles such as the artisanal fisheries carried out in tropical areas, as they are more inaccessible to management and long-term quantitative data collection ([Pauly and Zeller, 2016](#)). For example, countries that fish in tropical zones do not

even report fishing information to databases such as Ram Legacy ([Hilborn et al., 2020](#)). This platform compiles inventory data and management of fish stocks worldwide. For its turn, fisheries management in Brazil, which captures in tropical areas, do not provide any data on marine catches ([Nakamura and Hazin, 2020](#); [Ruffino, 2016](#)).

Brazil is a country of continental dimensions that includes a large portion of the tropical, subtropical, and temperate coast of the South-western Atlantic ([Marroni and Asmus, 2013](#)). Brazilian authorities refer to this marine area as the “Blue Amazon”; it is rich in biodiversity, fisheries resources (e.g., coast, seamounts, and oceanic islands), ecosystem services, and similar in extent to the country’s rainforest ([Soares et al., 2017](#)). In the last few decades, Brazil has implemented domestic and international initiatives to build a stable political and economic environment in the South Atlantic ([da Silva, 2017](#); [Scherer and Asmus, 2016](#)). Despite the apparent conservation goals of the Brazilian agenda and its ocean policies, there are underlying geopolitical and economic factors that must also be considered, such as securing

\* Corresponding author.

E-mail address: [belquior@alu.ufc.br](mailto:belquior@alu.ufc.br) (J.B.G. Neto).

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Brazil's oil, gas, and fisheries resources and consolidating its role as a major player in the ocean region (da Silva, 2017; Soares and Lucas, 2018).

The Brazilian fishing sector is an eternal promise of prominence in the world, although not significant in terms of gross domestic product (GDP), the fishing sector is important in other small levels that offer a great return, economically, cultural and socially (Abdallah and Sumaila, 2007). First, according to the latest official statistics (2011), Brazil produced around 553,670 tons (marine extractive sector) per year with the North and Northeast regions as the main producers of marine fish. The main fish species captured were: Brazilian sardinella (*Sardinella brasiliensis*) 75,000 annual tonne (t), Whitemouth croaker (*Micropogonias furnieri*) 43,000 t, and Skipjack tuna (*Katsuwonus pelamis*) 30,000 t (Brasil, 2011). However, this generalized data may not correspond to reality when we look at Brazil with its various divisions and particularities between artisanal (small-scale) and industrial fishing, in which the captured fauna is completely different. Some authors who have deeply studied the history of the fishing sector in Brazil have identified 3 main national fishery products among sardine, lobster, and shrimps (Dias Neto, 2010).

These groups of marine resources represent products of high commercial value (McCluney et al., 2019), but without precise quantitative long-term information (database) about the state of the stocks exploited by commercial or artisanal fisheries, it is challenging to generate fishery resource management plans or strategies to develop sustainable fishing. Brazil has an evident division as to the types of coastal fisheries carried out. While North and Northeast regions are predominantly characterized by artisanal, or small-scale, Southeast and South regions of Brazil have the largest industrial fishing activity in the country. This historical-cultural division in itself shows that the fisheries management carried out in a nation of such proportions (~9,200 km of coastline) should have a focus on adaptation and the socioeconomic reality of each region (Diegues, 2006).

Artisanal fishing is an economically important sector in terms of national employment, food security, business development, and currency gains (Lenselink, 2002). Brazil has more than 90% of active fishers belonging to the artisanal category, be it for subsistence or as a commercial activity. And even with this disparity in the distribution of activities, we will see that over the years, the industrial sector has always been prioritized to the detriment of small-scale fishing (Campos and Chaves, 2016; Ruffino, 2016; Schuhbauer et al., 2017). Nowadays, there is a need to make artisanal fishing more cost-effective while searching for ways to conserve fish stocks (Allison and Ellis, 2001). However, any management effort will be constrained and inefficient in the absence of fishing statistics and official data.

Brazil has not reported any official catch data to the Food and Agriculture Organization of the United Nations (FAO) since 2014 (FAO, 2018; Nakamura and Hazin, 2020). There is no national monitoring program or unified fishing database. Moreover, as will be presented and discussed in this paper, Brazil has a long history of political inconsistency in the mismanagement of its marine and estuarine fisheries. Furthermore, Brazil has recently suffered an institutional dismantling of the environmental sector (Abessa et al., 2019), which has further aggravated the unstable public management of fishing activity that has been neglected for some decades.

Unlike other countries that are leaders in fisheries production and technology, Brazil continues to neglect the planning and management of its fisheries (Farias and Farias, 2018; Gonçalves, 2019), especially the artisanal fisheries. Other initiatives around the world use co-management as an alternative for sustainable fisheries development (Melnychuk et al., 2021). Even with several obstacles, they are still more viable options in developing countries (Léopold et al., 2019; Russ, 2002). This disorganization has delayed the country's development in terms of improvement of a responsible fishing industry to the sustainability of activity and distributing financial resources for sectors that really needed it (Duarte et al., 2020; FAO, 2020).

This historical delay in several areas related to fisheries has left Brazil totally aimless in organizing the fishing sector, which should be a priority in a country with such a vast coastal and marine region. This paper will discuss past and present governmental inaction and critically discuss the damage caused by institutional disorganization and the lack of an official marine and estuarine fishing database to the Brazilian fisheries development, as a way to alert the public sectors to the need to restructure the fishing sector focusing on the governance of artisanal fishing. We will also propose, based on several calls from the scientific community, preliminary measures to fisheries management in Brazil, especially for the re-creation of a fisheries database for the extensive exclusive economic zone.

## 2. History - discontinuities in the fishing sector

The first normative acts in Brazil relating to fishing activity date from 1912. From this time until mid-1932, fishing activity was included under the Fisheries and Navy Actions Inspectorate (Fig. 1). From 1933 to 1961, it was under the Ministry of Agriculture. During the period of the military dictatorship until today, Brazilian fisheries policy focused on short-term productivity, that is, industrialism and capital concentration, a productive country, focusing on extraction and less on the efficiency or sustainability of fishing (Oliveira and Silva, 2012). These characteristics may have jointly contributed to an imbalance between fishing effort, with several rural subsidies granted for the development of the industry, and long-term sustainability of stocks (Abdallah and Sumaila, 2007; Dias Neto, 2010; Ruffino, 2016; Santos et al., 2012).

In 1962, the Fisheries Development Superintendence (SUDEPE), an autarchy of the Federal Ministry of Agriculture, was created (Fig. 1). In 1989, in the post-re-democratization period, the publication of Law No. 7.735 created the Brazilian Environment Institute (IBAMA) by merging SUDEPE with three other institutions: the Brazilian Institute of Forestry Development, the Superintendence of Rubber, and the Secretariat of the Environment of the Presidency of the Republic (Fig. 1).

In Brazilian political history, several sectors served as a front for the interests of more favored classes. This also happened with the fishing sector. Even during the management of SUDEPE, several problems of corruption, mismanagement, and lack of budget for a good institutional performance were reported (Dias Neto, 2010; Ruffino, 2016). Since 1989, the fisheries sector has undergone sudden and substantial top-down changes. SUDEPE focused strictly on the economic and social aspects of the sector, but after the creation of IBAMA, the focus shifted to the management and conservation of fish stocks (Fig. 1). This remit included fishing closures (closed areas/seasons) to protect species' reproduction, the implementation of minimum catch sizes, limits on the number of fishing licenses for certain fish stocks, and the prohibition of predatory fishing gears. These terminologies were 'new' and unknown to the vast majority of the multiple stakeholders in the supply chain, with the result that the changes were not well accepted, and there were many setbacks to their effective implementation. In this way, IBAMA had exclusive control over the sector until 1998 (Fig. 1).

In 1998, the Department of Fisheries and Aquaculture (DPA) was created by the Ministry of Agriculture, Livestock, and Supply (MAPA) (Fig. 1). It absorbed some of the IBAMA's responsibilities, with the objective of identifying ways to improve the productivity of fishing activity. The DPA worked in the sector until 2002. In 2003, the Special Secretariat for Aquaculture and Fisheries of the Presidency of the Republic (SEAP/PR) was created, which, in turn, absorbed MAPA responsibilities and many other duties related to the organization of fishing activity (Fig. 1).

In mid-2009, with the inauguration of the Ministry of Fisheries and Aquaculture (MPA), created by Law No. 11.958 of June 26, 2009, and the National Policy for Sustainable Development of Aquaculture and Fisheries, the most substantial institutional changes in the sector occurred. During this period, it was possible to verify new objectives for the sustainable development of the sector, especially through the main



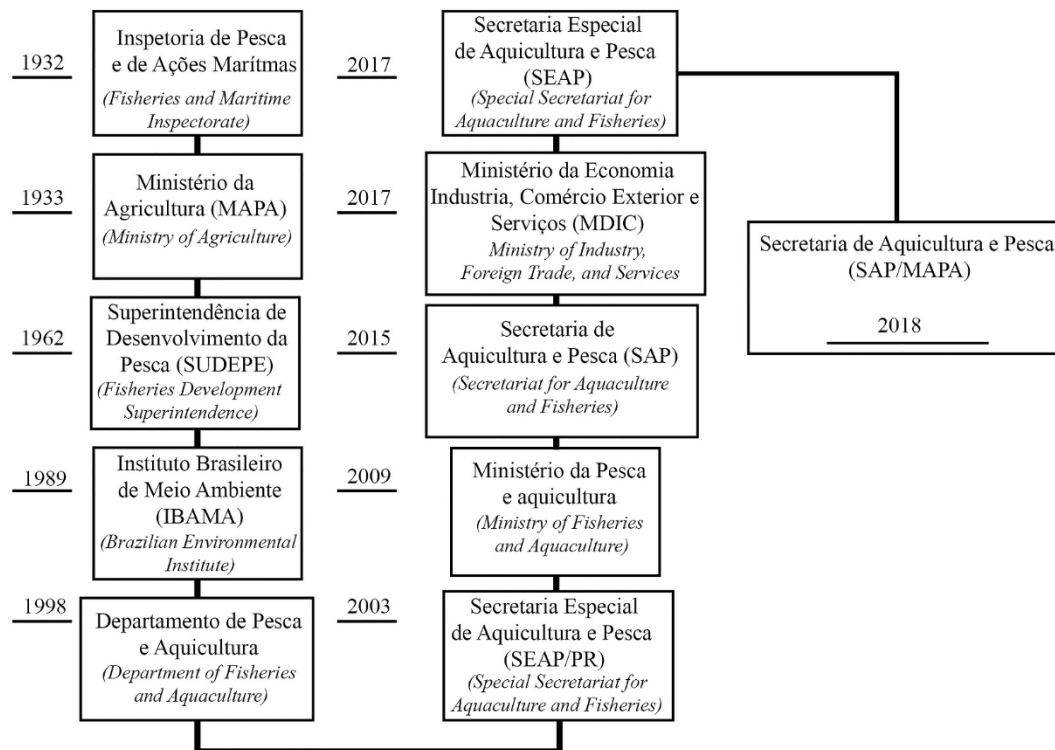


Fig. 1. Example of historical discontinuity in the management of the Brazilian fishing sector.

change, shared management between the MPA and the Ministry of the Environment (MMA), who were now jointly editing and publishing regulations concerning fishing and aquaculture. This shared procedure was regulated by Decree No. 6981 on October 13, 2009. However, although we have observed efforts by the political class to develop the sector through the creation of a specific ministry for fishing activity, the ministry has been widely used with a political bias towards voters and has added the hidden interests of its leaders to its public policies. In this way, a clear example of this corrupt machinery was uncovered by the “entangled” operation by the Federal Police in 2015, who dismantled a possible criminal organization that worked with the MPA and IBAMA. The operation culminated in the arrest of several civil servants and business people under suspicion of selling illegal fishing licenses to vessels as well as quotas for the capture of effort-controlled species (Federal Police, 2015).

Since 2015, the activities inherent to the sector have been the responsibility of MAPA, through the creation of the Secretariat of Aquaculture and Fisheries (SAP/MAPA). However, the continuation of shared management with MMA should be highlighted. In 2017, the SAP was transferred to the Ministry of Industry, Foreign Trade, and Services (MDIC) through a provisional measure, which, when reviewed by the national congress, transferred it again, recreating SEAP. SEAP was initially an independent body within the Presidency of the Republic (Law No. 13.052, November 1, 2017), but Decree No. 9.330 of April 5, 2018 allocated it to the Secretary General of the Presidency of the Republic. Currently, Decree No. 9.667 of January 2, 2019 establishes that SAP is an organ of direct and immediate assistance to the Minister of State of Agriculture, Livestock, and Food Supply, and is, therefore, part of the MAPA organizational structure (Fig. 1).

Even with a radical right-wing political change (2018), the sector responsible for fisheries in Brazil remains as a bargaining chip between political parties, dissipating national interests in particular interests (Abessa et al., 2019; Dias Neto, 2010). There are no targeted efforts on building a national recovery plan, or for the first time, functional sector organization. Brazil should focus on the basics to start a science-based fishing governance strategy.

From the 1960s to the present day, the fishing sector has never been centralized for long enough to muster the effort and investment necessary for its proper long-term development. This fragmented history means that the management of the Brazilian fishing sector remains discontinuous and ineffective (Fig. 1). The USA runs a state-based fisheries management system, but with some federal oversight. In legislative terms, unlike countries like the USA, Brazil does not have states with autonomy of legislation in matters with federal regulations, such as fishing. It is exclusively up to the national congress with the presidential sanction to dispose of the union’s assets, and the sea and its management are included in that. We consider it a complex issue, but we believe that the top-down centralization of fisheries regulation and management makes it difficult to take effective actions along this extensive exclusive economic zone.

In political terms, fisheries management in Brazil is uniquely and exclusively centralized as a union asset (Federal level). This generates several conflicts regarding the management of fisheries resources in the seventeen (17) Brazilian coastal states. A recent example occurred in the State of Rio Grande do Sul, which prohibited bottom trawling, mainly due to the high level of discards, but due to the Supreme Court’s Federal decision, the state law was revoked, because the regulation of the sea belongs to the federal government (Globo, 2021). With all its divisions and partitions, there is a lack of a solid basis for assessing stocks for the future of the sector and assist traditional communities that need special attention, such as artisanal fishers.

### 3. Fishing data - starting almost from scratch

The institutional neglect of the Brazilian fishing sector is a chronic problem. Brazil could be one of the world’s leading economies in artisanal fishing activity thanks to several favorable factors. These include a vast coastline (Barreto et al., 2017; Marroni and Asmus, 2013), a variety of fishing grounds (e.g., sandy beaches, estuaries with extensive mangrove forests, shelf breaks, shallow-water coral reefs, rhodolith beds, seamounts, seagrass beds, and oceanic islands), and a great diversity of species of both industrial and artisanal interest (Messias et al.,

2019). A major category to be explored and developed is artisanal fishing, particularly livelihood fishing (the type of fishing carried out by small communities catching fish only for their own consumption or small-scale sales).

For a sustainable use of national marine resources, despite all the regulations and subsidies provided for fishing in other times, Brazil needs to start from the basics again, including data collection (Zabala, 2018). When dealing with national fisheries management, the discussion always gets in the way of subsidies for fleet improvement, and never for the basics, such as the current status of fish stocks and the current health of marine and coastal ecosystems (Reis and D'Incao, 2000). Although there are broader initiatives for the construction of a National Shared Management Plan (Seixas et al., 2011), little is done at the federal level for structuring and standardizing the sector, especially the basics, which include long-term database on fish stocks and spatial analysis of fisheries activities.

A database, even if primary, is a first step in determining the logistics of fisheries actions (Freire and Pauly, 2015). Other factors such as public policies to include fishing communities in bottom-up decision making, as well as co-management between states, stakeholders, municipalities, non-governmental organizations (NGOs), universities, and fishing communities (Dias Neto, 2010; Evans et al., 2011; Hazin, 2006; Reis-Filho and Antoine O L, 2017; Silva et al., 2013). However, all of the management actions depend on science-based knowledge about what we fish, where we fish, how we fish and who fishes.

Even in developed countries, illegal, unreported, and unregulated (IUU) fishing occurs (Ainsworth and Pitcher, 2005). However, there are still viable solutions for efficient fisheries management (Claudet et al., 2020), which could reverse the damage caused to overfished stocks and prevent the collapse of this important sector of the blue economy (Cisneros-Montemayor et al., 2019; Costello et al., 2008). The presence of a national fishing database is essential for the analysis of stocks as well as the ecological health of marine and coastal ecosystems.

Adequate public policies such as long-term data collection can reduce IUU fishing and encourage the development of legal activity and training for those involved in the fishing sector (Batista et al., 2014; Chu et al., 2017; Melnychuk et al., 2020). Such regulation can also provide a historical basis for the status of exploited populations from which to understand the current status of each species or target group, such as tuna and tuna-like species (Fromentin, 2009). This historical delay in several areas related to fisheries has left Brazil totally aimless in organizing the fishing sector, which should be a priority in a country with such a vast exclusive economic zone.

In Brazil, there are currently no official data on fisheries stocks, their spatial and temporal production, or fishing efforts, and even less data on the pressure on natural stocks (Damasio et al., 2015; Previero et al., 2013). Information on exploited stocks is crucial for understanding the actual conditions of target species in fisheries (Freire and Pauly, 2010; Jayasinghe et al., 2017). Despite efforts between 2003 and 2010, with the creation of a specific ministry and collection of fisheries data, political instability in Brazil did not provide the unified basis for organizing logistics to continue monitoring programs (Brasil, 2011; Gonçalves, 2019; Ruffino, 2016). Without adequate knowledge, or a national fisheries data management program, fish stocks can show unpredictable catches over almost a decade of lag. A reliable science-based updated database enables the fishing industry, artisanal communities, and the government to adequately manage the future of the resources and the fishing activity itself.

Today, various information's about the Brazilian fishing sector are contradictory. According to the FAO, Brazil has not sent official data reporting its fishing activity, such as catch volume, species caught, or information about its fishing fleet, since 2014 (FAO, 2018). However, the last official federal report on fishing and aquaculture in Brazil is from 2011. There are at least six or nine years in which estimated data was used instead of real data collected with a robust methodology from fisheries capture and management in Brazil. This situation is even more

complicated when it involves artisanal fishing in which there are no catch spatial and temporal patterns along the extensive Economic Exclusive Zone (3.6 million of km<sup>2</sup>) or information from on-board vessels.

Even for tuna and tuna-like species or coastal resources, such as snappers, that are widely consumed by Brazilian and international markets (Brasil, 2011; Messias et al., 2019), real and updated information about their capture at a national level is lacking or underestimated. For these species of economic interest, such as tuna, according to the International Commission for the Conservation of Atlantic Tunas (ICCAT), Brazil continued to provide data until 2018, but their engagement has increasingly declined due to a lack of measures to manage such resources (Gonçalves, 2019). This may be the only source of data at the national level, but it does not account for catches other than tuna and related species. In addition, it does not accurately reflect the capture volume, or fishing fleet active in Brazilian waters. According to the ICCAT's 2020 reports, there are only 361 vessels active in the Brazilian coast, while FAO online platform (Fishing vessels finder) reports 138 active vessels with the Brazilian flag, a number too small to represent the entire national coast. Still, in the last FAO report (2020), unofficially official government websites report about 20,000 fishing vessels (Brasil, 2020). Due to the lack of accountability on fishing data, Brazil is not included in the list of countries with active fishing vessels. This can send a wrong message about the unsustainable exploitation of our fishing resources, mainly coastal.

For this reason, there are several initiatives focusing on marine fisheries exploitation in different regions, and these programs are compiling and restructuring fisheries data for a better understanding of stocks, discards, and future fisheries management (Bhathal and Pauly, 2004; Zeller and Pauly, 2007). Co-management projects (e.g., inside the marine protected areas - MPAs) are also effective, especially in artisanal marine and estuarine fisheries production and data collection (Coelho Dias da Silva et al., 2010; Silva et al., 2013). Co-management can reduce the risks of fishing to the environment, as well as making the artisanal community a key protagonist in the activity (Diegues, 2008; Linke and Bruckmeier, 2015; Seixas et al., 2011). In this way, it is possible to design several types of long-term projects for the conservation of species, the development of various fishing arts, and even the statistics of artisanal fisheries production, thereby reducing the misinformation about what is caught.

To this end, government bodies should establish national and regional action plans to combat fraud, irregular, illegal, or unreported fishing (Barreto et al., 2017), and battle corruption in the sector as well as improve the proposed sanctions (Gallic and Cox, 2006). Such measures, with cooperation from society and multiple stakeholders, can contribute to the consumption of products with guaranteed traceability and sustainable fishing. The artisanal fishing communities must be considered given their close relationships with the main nearshore fishing zones. In this way, management models that use effective tools and data-based foundations for fisheries management should be applied to achieve the sustainable development goals (SDGs).

Based on the United Nations SDG 14 for sustainable development "conserve and sustainably use the oceans, seas and marine resources for sustainable development" (Nakamura and Hazin, 2020), we believe that effective fisheries management should be based on the three pillars of scientific, economic, and social development (Asche et al., 2018). Each of these pillars will encourage the science-based development of activities that will benefit fisheries management as a whole. When investment covers all three of these objectives, it will be possible to carry out programs to promote the sustainable growth of the fishing sector in its numerous areas of activity along the Brazilian coast (Fig. 2).

#### 4. Current status of the fisheries sector in Brazil

The neglect of the Brazilian fishing sector has already been addressed by several authors (Table 1). However, in the last 10 years, little has



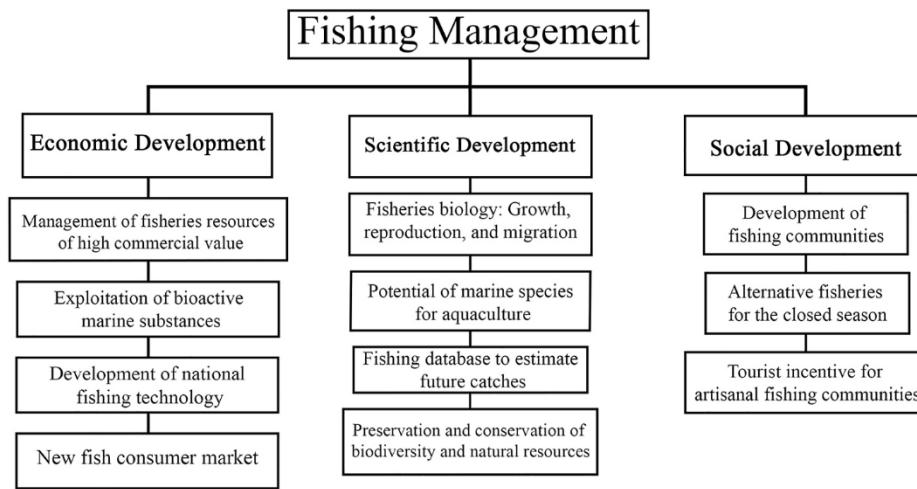


Fig. 2. Main goals and objectives for governance of the Brazilian fishing sector in the United Nations Decade of the Ocean Science for Sustainable Development (2021–2030).

Table 1

Summary of publications raising concern about the history and misdevelopment of the Brazilian fishing sector.

Author	Theme	Format	Year
Abdallah (1998)	Fishing activity in Brazil: policy and evolution	Thesis	1998
Hazin (2006)	Fishing in the Exclusive Economic Zone - EEZ: its importance for Brazil	Article	2005
Boeckmann and Geber (2006)	Proposals for sustainable development of the fishing sector in the state of Pernambuco, with the support of tax incentives	Article	2006
Diegues (2006)	Artisanal Fisheries in Brazil	Report	2006
Abdallah and Sumaila (2007)	An historical account of Brazilian public policy on fisheries subsidies	Article	2007
(Dias Neto, 2010)	Management of use of marine fishery resources in Brazil	Book	2010
(Hazin, 2010)	The future of marine fisheries and aquaculture in Brazil: ocean fishing	Article	2010
(Castello, 2010)	The future of marine fisheries and aquaculture in Brazil: coastal fishing	Article	2010
(Oliveira and Silva, 2012)	The process of industrialization of the fishing sector and the destructuring of artisanal fishing in Brazil based on the 1967 Fisheries Code	Article	2012
Silva et al. (2013)	Resolving environmental issues in the southern Brazilian artisanal penaeid- trawl fishery through adaptive co-management	Article	2013
(Freire and Pauly, 2015)	Reconstruction of fishing, Brazil 1950–2010	Article	2015
(Reis-Filho and Antoine O L, 2017)	Management-Challenged Brazilian Governance and the Low Relevance of National Fishery ManagementPolicy: Recommendations to Promote Viable SmallScale Fisheries	Article	2017
Farias and Farias (2018)	Comparative Performance between Fish Exporting Countries in International Trade: Brazil efficient?	Article	2018
Leis et al. (2019)	Mapping fishers' perceptions of marine conservation in Brazil: An exploratory approach	Article	2019
Jimenez et al. (2019)	Understanding changes to fish stock abundance and associated conflicts: Perceptions of small-scale fishers from the Amazon coast of Brazil	Article	2019
Nakamura and Hazin (2020)	Assessing the Brazilian federal fisheries law and policy in light of the Voluntary Guidelines for Securing Sustainable Small-scale fisheries	Article	2020

been done in this regard.

Among economic approaches, evidencing the low relevance in terms of exports of fisheries resources (Farias and Farias, 2018), i.e., in historical surveys, drawing parallels with the current state of the fisheries sector in Brazil, which is at the mercy of private sector interests and used as a bargaining chip between governments (Dias Neto, 2010). Politically and institutionally, the sector has never functioned adequately for the purposes of sustainable fisheries development. Even between the years of fiscal incentives between the 1960s and 1980s, with the creation of public agencies specifically to designate fisheries management, the *modus operandi* of Brazilian policy corrupted and bureaucratized bodies that, in practice, suffered from low budgets and government barriers to structure them with trained technicians and specialists (Dias Neto, 2010; Ruffino, 2016). In addition, there are cases of corruption that still exist today in the sector, and have been reported in previous years (Reis-Filho and Antoine O L, 2017). A recent case is the fight against fraud in the inefficient distribution of closed insurance; subsidy for fishers in times when it is not possible to fish for certain species due to reproductive activity.

Many current approaches reinforce the need for a comprehensive and multidisciplinary logistics for fisheries management (Reis-Filho and Antoine O L, 2017). At least 10 years ago, the difficulty of centralized fisheries management had already been highlighted (Dias Neto, 2010; Léopold et al., 2019; Vasconcellos et al., 2007). Even at the state level, the subsidies needed to develop the sector, i.e. training and improvement of neglected artisanal fisheries, do not adequately reach those who really need them (Boeckmann and Geber, 2006). But what is already known is that to start a real effective management one must invest, mainly, in the capacity building of fishing communities, from the most basic, such as reading and writing (education), as well as organizing the productive socioeconomic bases, such as cooperativism, for example (Hazin, 2006).

Even with 10 years of delay in relation to official national data, some specific states secretariats updated data on the capture of marine fish. The state of Ceará (northeastern Brazil), for example, shows that between 2016 and 2020 tuna exports grew from \$ 653,226 to \$ 4,122,453. Moreover, in the last 10 years, fish exports (except tuna) have risen from 2,770,380 dollars to 22,586.985 dollars in this state. Also in 2018, the State Government of Ceará invested approximately 6.8 million reais (approximately 2.1 million dollars) in the state's fishing sector, mainly in the investment in new equipment and aid to fishing communities (Ceará, 2018).

Unlike initiatives like this to maintain life activity, at the federal level Brazil spent about 17 years without legislation that effectively impacted

the fishing sector between the 1960s and 1980s (Abdallah, 1998). From the 1980s to today, almost nothing has changed. Fisheries legislation remains based on outdated legislation. Even with the new proposals by the Voluntary Guidelines for Securing Sustainable Small-scale Fisheries suggested by FAO, little has been done at the level of action by the federal institutions responsible for the fishing sector (Nakamura and Hazin, 2020).

Some steps have already been taken in recent years to try to rebuild national fisheries and foster data for a new base from which to start (Freire and Pauly, 2015). However, over the years, scientific knowledge has always been neglected or has not adequately reached real decision-makers (Dias Neto, 2010; Nakamura and Hazin, 2020; Ruffino, 2016). This obstacle can be tackled when there is shared management of responsibilities among the sectors that manage fisheries in Brazil. Some methodologies that integrate fishers knowledge into decision-making for the management of exploited resources have already shown positive results in some primary parameters for the design of an applicable model (Leis et al., 2019; Reis-Filho and Antoine O L, 2017; Silva et al., 2013). Because of its continental dimensions, monitoring all fishing landings in Brazil should be a cooperative and collaborative effort between states and municipalities to reduce misinformation about the country's fishing catch. In Brazil, because of the lack of project continuity and a failure to develop the required activity, it has not been possible to achieve integration in fisheries at the regional and national levels (Previero and Gasalla, 2018).

Despite this, we have good examples of national fisheries monitoring programs like such a major project, ESTATPESCA. It was used as a reference for the statistical fisheries bulletin in Brazil. First introduced in the northeast of Brazil, it carried out the collection of fishing information (e.g., types of vessels and fishing gear, catch volume, days at sea, CPUE – catch per unit effort) at specific points along the tropical coast of Brazil. The ESTATPESCA Program (Fishing Activity Monitoring Program on the Brazilian Northeastern Coast) was based on FAO studies to obtain statistical data on the fishing sector (Aragão, 2008; Aragão and Castro e Silva, 2006). This program was first implemented to collect long-term fisheries data in the Northeast and North regions of Brazil, and later also applied to all coastal states in the country (with the exception of São Paulo state). The unified program conducted various sampling procedures on fish landings and was aimed at assessing fishing, especially small-scale activity, by the artisanal communities.

Other projects, such as PROFROTA (National Program of Finance for the Development and Modernization of the National Fishery), have tried to develop public policies for investment in fishing technology and the modernization of the sector. However, even projects such as PROFROTA, which aimed to develop fishing in Brazil, continued with an industrialist approach and focused on medium or large scale fishers (Abdallah and Sumaila, 2007).

In 1982, Brazil signed and in 1988 ratified the United Nations Convention on the Law of the Sea. Therefore, it made a commitment to the national and international community related to the exploration, utilization, conservation and management of the living resources of the Exclusive Economic Zone (EEZ). From this, the Program for the Evaluation of the Sustainable Potential of Living Resources in the EEZ (REVIZEE) was created, which began in 1995 and lasted 10 years, with the participation of Ministries, Universities and Research Institutions. The main objective was to survey the sustainable potential of capturing living resources in the EEZ (Haimovici et al., 2006).

Over the years along the Brazilian coast, some steps have been taken in the search for the construction of a broader development plan for participatory management in fisheries, through fishing forums or marine extractive reserves (*Resex* in Portuguese) (Kalikoski et al., 2007; Seixas et al., 2011). These projects identified possible conflicts, management measures, development of fishing activity in different regions of Brazil, and concluded that, despite the conflicts inherent in any decision making and management, there are possible solutions when the stakeholders act directly in the bottom-up construction of a effective

management plan (Evans et al., 2011). Yet, there is a consensus that, in this co-management, the government should act as a unifier, but, mainly, initiate a basic data collection on fishing and marine extractive activity.

In addition to the need for monitoring, we are running out of time. Several fishing resources, mainly coastal, have already collapsed in Brazil (Jimenez et al., 2019). The sardine is one important example, one of the main national fishing resources that collapsed in the 1990s (Freire and Pauly, 2015). Therefore, one of the ways suggested by Hazin (2006), for example, is to invest in the capture of more oceanic species, which have greater commercial value and thus diversify exploitation in national waters. Since the 2000s, there have been concerns about the exploitation of fisheries above the maintenance capacities of some species in Brazil (Freire, 2005). The problem may be worse today, but without sufficient long-term data, it is impossible to know how target species populations are faring. The national fishing industry also shows clear signs of decay when export figures are assessed. Brazil shows commercialization rates well below those of countries that view the fishing sector as fundamental for development (Farias and Farias, 2018).

## 5. What can be done?

### 5.1. Social and ecosystem levels

The international scenario is already moving toward a categorical change in the current practices of the fishing sector. The main intention is to make fishing a more sustainable activity that encourages gender equality, sustainable fishing, and inclusive economic development (Cámara and Santero-Sánchez, 2019; Torre et al., 2019). Other objectives are to increase investment in technology, science, focus on food security for human consumption (to alleviate hunger), and prioritize responsible production and consumption (Garcia et al., 2018; Garcia and Ye, 2018).

In this context, it is known that the Brazilian fishing sector is on the verge of collapse in economic, social and ecological terms (Dias Neto, 2010; Farias and Farias, 2018; Jimenez et al., 2019) and that some types of fishing continue to be responsible for the degradation of resources and marine ecosystems (Freire and Pauly, 2010). However, it would be possible to reduce this human impact with management measures supported by a decrease in pressure on already collapsed fish stocks at the industrial level (Dutra et al., 2011; Pauly et al., 2002). It is feasible to reconstruct marine populations, fish stocks, or marine ecosystems at local levels, with customized management regimes (Duarte et al., 2020) in the ongoing United Nations Decade of Ocean Science for Sustainable Development (2021–2030).

Co-management, which adapts different realities to the common goal of sustainable fishing, can be effective (Batista et al., 2014; Bockstael et al., 2016; Memarzadeh et al., 2019). Investing in artisanal fishing and the development of fishing communities, with the help of the State, municipalities, NGOs, and private entities, can generate valuable environmental and social returns (Jimenez et al., 2019; Tursi et al., 2015). This approach also encourages the inclusive economy through small production chains and adds value to the specific products of each region.

All over the world there are conflicts in small-scale fishing that are shared between developing countries. However, the co-management of fishing activities has shown benefits in the resolution of these conflicts at the expense of centralized management, which does not give voice to stakeholders (Evans et al., 2011; Jimenez et al., 2019). Fisheries management in Brazil could decentralize decision-making based on the needs and main conflicts of each state in the country.

Currently the main bottlenecks in common, in several realities of the Brazilian coast, for the development of co-management are: Deficient inspection, Difficulty in reconciling different interests, Ineffective or unclear rules, and the lack of knowledge of the cultural activities of the fishers' community (Seixas et al., 2011). The main characteristics cited by the literature for a good functioning of co-management applied in



pilot models in Brazil are: Defined limits for interested parties; Collective choices for sea use; Penalties; Well-defined hierarchy, and mainly usage monitoring. In this way, some measures such as the creation of fishing forums (unregulated activity that introduces the community as a mediator of the conflicts themselves) can be implemented.

Developing artisanal fishing does not necessarily induce an indiscriminate increase in catches. The implementation of co-management programs directly influences the sustainable management of resources exploited by small-scale fisheries. It may even increase the abundance of fish exploited by less industrial fishing (d'Armengol et al., 2018), and in general terms, other developing countries demonstrate that the implementation of co management in artisanal fisheries gives better results in governance.

In regions where major activities depend on ecosystem integrity, such as fishing and tourism, the integration of social, economic, and environmental aspects for sustainable development is fundamental (Dutra et al., 2011; Seixas et al., 2011). In this context, area-based management should be encouraged as they represent utmost opportunities for conservation and sustainable development. The establishment of area-based management promotes ecotourism and restores fish stocks, thus conserving biodiversity while increasing biomass (Russ, 2002; Russ et al., 2004). There are several examples in the literature demonstrating that marine reserves of various sizes increase artisanal fisheries production (Francini-Filho and Moura, 2008).

The Corumbau Marine Extractive Reserve is a good national example of environmental benefits combined with improved fisheries management (Dutra et al., 2011). Local traditional fishers have exclusive rights to the area, fishing boats from other regions are prohibited, and there is a 'no-take' monitored zone. After five years, it was observed that important commercial species, such as the black grouper *Mycteroperca bonaci*, had shown a significant increase in abundance, not only in the 'no-take' area but also near its limits (Francini-Filho and Moura 2008; Moura et al., 2007).

There are some other co-management proposals that can regulate and assist in the shared use of marine resources with the use of other extractive marine areas: Resex of Salgado Paraense: Reserva da Mãe Grande (Pará); Resex de Soure, on the Marajó Island (Pará); Caeté-Taperaçu (Pará); Tubarão Bay (Maranhão); Delta of Parnaíba, (Piauí); Batoque (Ceará); Prainha do Canto Verde (Ceará); Jequiá Lagoon (Alagoas); Iguape Bay (Bahia); Ponta do Corumbaú (Bahia); Arraial do Cabo (Rio de Janeiro); and Pirajubá, Florianópolis (Santa Catarina) (Vasconcellos et al., 2007).

Despite the conflicts inherent in co-management, co-participation is a bottom-up solution to bring the responsibility of managing marine resources to the main sectors active in the exploitation of ecosystems: artisanal and industrial fishing, fishing community, private sector (tourism, hospitality), academic institutions and governments municipal, state and federal. Involving poor fishing communities in this type of resource management is critical to the maintenance of local economies and the development of small communities. It is also essential to conserve marine ecosystems without compromising the social justice associated with less-favored traditional communities dependent on ecosystem integrity for food security (Almudi and Kalikoski, 2010). Artisanal fishing represents not only the economy of the sea but also many local cultural qualities in developing countries (Tietze, 2016).

## 5.2. At the level of artisanal fisheries

Although artisanal fishing has an impact on marine biodiversity (Diegues, 2006), there is evidence to support that the idea of co-management and implementation of MPAs can assist in this impact and in maintaining the activity (Schafer and Reis, 2008). But, mainly, the state is a key factor to supply certain spaces that can arise in the logistics of this shared management (Batista et al., 2014).

As elsewhere in the world, artisanal fisheries management is somewhat complex (Trimble and Berkes, 2015) and slow to implement

(Batista et al., 2014; Seixas et al., 2011). However, for the Brazilian state, the fishers have always been held hostage to policies that subsidized the development of fishing based on private interests (Dias Neto, 2010). Developing this fraction of the fishing sector directly strengthens traditional communities, which often live in conditions of poverty, as well as focusing on a portion that has always been forgotten in the Brazilian fisheries management (Béné et al., 2010).

The development of strategies for shared use of marine resources based on co-management can reduce existing conflicts (Coelho Dias da Silva et al., 2010; d'Armengol et al., 2018). There is no simple solution for implementing projects that often interfere with a local historical culture of enjoying fishing zones (Batista et al., 2014). However, after adapting specific realities, it would be possible to develop projects for this management to occur in a less conflicting way, and aligned with the sustainable development of ecosystems as MPAs. Although neglected, it is an important tool in economic development (Araujo et al., 2017; Damasio et al., 2020). These involve ecosystem-based fishing (Pikitch, 2004) and directing fishing sector investments towards priority areas (Rudd, 2004), as a budget increase in research (Seixas et al., 2011), qualification and training of communities (Hazin, 2006) that live on the basis of artisanal fishing, either for their subsistence or for trade (Campos and Chaves, 2016). The training and qualification of the professionals involved in the fishing sector is also an important point to reduce the communication noise between the interested parties. This qualification directly involves the basic teaching of biological, technological and economic concepts important for fishers to understand the importance of data production for the prosperity of the activity (Reis and D'Incao, 2000). In addition to this, for a good co-management practice for the sector fishing, the absorption of the traditional ecological knowledge of these fishermen for decision making would be a great benefit.

In this case, the investments in human resources may be perhaps the best basic investment for fisheries governance. Furthermore, as always implemented when talking about the development of the Brazilian fishing sector, financial investment in structure are crucial for fishing fleet improvement, such as more selective fishing gear (Afonso et al., 2011), avoiding bycatch, and less harmful to the species caught (Coelho Dias da Silva et al., 2010). Moreover, investments are essential for gathering information which can be useful for a first management plan, with basic data on "what, where, and how we fish", which ecosystems and stocks are most exploited, which fishing communities have conflicts with industrial fishing, which areas are most conducive to co-management, and to fulfill the main needs of the fishing sector at institutional and operational levels.

Another useful tool to focus on sustainable fisheries development is ecological risk assessment, which infers the probability of adverse effects from exposure to one or more human stressors. In this approach, data, information, assumptions, and uncertainties are systematically evaluated and organized to understand and predict the relationships between stressors and ecological effects for environmental decision-making (EPA, 1998; 1992). Within this framework, an ecological risk assessment of fishing effects has been established (Hobday et al., 2011) to identify and prioritize risks to coastal and marine ecosystems by commercial fisheries and allow science to focus on the most urgent ecological information needs. This analysis can favor sustainability and environmental status, securing yields, and making fish more attractive to consumers from an environmental perspective (Cotter and Lart, 2011).

## 5.3. Public policies

In Brazil it is already known that public policies with a single focus on economic subsidies, tax incentives and investment in production are not viable neither for the maintenance of the fishing sector, nor for the health of the exploited stocks (Abdallah and Sumaila, 2007; Nakamura and Hazin, 2020). Public policies such as REVIZEE and ESTATPESCA

(section 4 of this paper) are examples of how Brazil can responsibly manage marine resources (Lessa et al., 2004, 2009).

In addition, international policies for the fishing sector try to reconcile all the parameters governing the activity, including the economic, environmental, cultural, and social aspects (Coulthard et al., 2011). Public policies aimed at decentralizing responsibility for fisheries management can help an institutional sector that is overburdened. Sharing responsibilities with states, municipalities and other entities related to fishing NGOs and Universities, can contribute as in previous projects. The federal scope can continue as a moderator, and a summary of projects and legislation focused on industrial and artisanal fishing. Although the fishing sector continues to be an obstacle with responsibility totally concentrated at the federal level, there are examples of laws that encourage interaction between States, Municipalities, Academic Institutions and NGOs (Law No. 12,187, of December 29, 2009). This law refers to the development of activities to combat climate change. Examples like this can be developed to unburden the federal level and share management in the hierarchy of minors. For this reason, we believe in a public policy that develops a preliminary database on marine ecosystems and fishing so that actions can be mediated based on scientific knowledge in conjunction with the needs of professionals in the field.

As mentioned above, the Brazilian government has already carried out several fiscal incentives at different times, and these incentives have been proved ineffective on sustainable development and longevity of the activity. The lack of fisheries management has affected the activities within the sector in various ways. Over the years, institutional neglect, with ministries and secretaries used as political bargaining chips, has been symptomatic of a lack of sincere interest in the industry's growth. It has held back the economic development of the sector, especially artisanal fishing, and hindered conservation of fishing-affected marine environments. Therefore, based on all the calls already made by other experts in the field over the years developing public policies for the subsistence of artisanal fisheries must be done in conjunction with the training and qualification of the professionals involved, fishing community, fishermen, technicians, boat owners, business owners, social workers, merchants, the scientific community and decision makers. Before transforming the activity, it is necessary to provide livelihoods and government support for the security of small-scale fisheries (Béné et al., 2010). The lack of institutional organization on artisanal fishing also contributes to greater ecosystem damage and less sustainability (de Freitas et al., 2017).

Correctly applied logistics and well-defined functions can optimized investments to be applied with greater efficiency as well as a union between the management of current legislation and logistics for fisheries development (Nakamura and Hazin, 2020).

### Final considerations for Brazilian fisheries development

As we enter the United Nations Decade for Sustainable Development of the Oceans (2021–2030), we believe that it is possible to reverse the historical picture of neglect with a sector of the economy that encompasses many people. In addition, a national management plan first needs a review of everything that has been done so that we can draw up new methodologies that are in line with new marine resource management policies and the blue economy, like restoring habitats, protecting species, and harvesting wisely (Duarte et al., 2020).

Another measure at the national level, but which can assist in international policies for the implementation of sustainable fisheries, is to urgently initiate a science-based plan, even if basic, for the collection of fisheries data at the national level. A minimum database is required to initiate assessments of the current status of captured stocks, mainly due to the variety of species caught in coastal areas (Freire and Pauly, 2010, 2015; Zabala, 2018), as well as information about the ecosystems explored. This database may also assist international levels in fisheries management in the South Atlantic Ocean.

The fishing sector itself, in a country with continental dimensions like Brazil, is very complex. To help the neediest link in this sector, small-scale fisheries, we believe in co-management and division of public responsibilities between municipal, state and federal public authorities. Even though the use of MPAs is not a consensus regarding easy and fast management, often increasing the complexity of management (de Oliveira Leis et al., 2019), other studies already indicate positive results when we assume the necessity of planning for co-management, and adaptability to the current reality of the stakeholders (Batista et al., 2014; Moura et al., 2009; Seixas et al., 2019). In order to standardize and facilitate the collection of fisheries data, financial incentives to communities and foster cultural monitoring of fishing activity in conjunction with sustainable fishing are important. An institutional change in the management of Brazilian fisheries is urgent with the states as the protagonists and at the federal level public policies to data management, income distribution for social projects and improvements in traditional communities to foster other sources of income during closed fishing seasons.

Policymakers and managers must understand that the majority of artisanal communities maintain old fishing traditions and that in order to develop the sector, it is necessary to present adequate proposals for maintenance of the activity (Seixas et al., 2019). Ideally, with the support of community leaders, training should be conducted to implement the following logistical model. In this way, we believe that artisanal fishing could become an active and collaborative activity that supports the maintenance of a system beneficial for the fishery industry, scientific knowledge, and the development of fishing communities, as has been achieved by other countries (Garza-Gil et al., 2019; Léopold et al., 2019; Melnychuk et al., 2021; Messias et al., 2019; Trimble and Berkes, 2015).

In conclusion, we have discussed the past neglect of the fishing sector in one of the world's largest countries and explained that, for at least 10 years, the scientific community has been warning about the importance of properly organizing and managing the fishing sector. Despite the social and economic significance of commercial and, especially livelihood marine artisanal fisheries, the depreciation of collective interests to the prioritization of interests of particular sectors is evident in the disrupted history of its various public administrations. This discontinuity has prolonged, by years, the lack of knowledge about the South-western Atlantic Ocean, and the possible overfishing of regional fish stocks and made it impossible to guarantee the sustainability of this important blue economy sector. However, small efforts at state levels, marine protected areas, and in small communities have been made to identify the main conflicts and ways of solving these problems, adapting to the local reality, and collecting primary data for assessing fish stocks and ecosystem health. These measures are the cornerstone for an alert for joint management as a viable solution for the sustainability of the fishing activity in Brazil.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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