Vol. 63, p. 48-65, jan./jun. 2024. DOI: http://dx.doi.org/10.5380/dma.v63i0.90561 e-ISSN 2176-9109

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Remodeling the demersal fishery management system of southeastern and southern Brazil

Uma proposta de reforma da gestão da pesca demersal no Sudeste e Sul do Brasil

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Article received on March 31, 2023, final version accepted on July 24, 2023, and published on March 15, 2024.

ABSTRACT: Demersal fishing in southeastern and southern Brazil has expanded since the 1990s to include a variety of fish and shellfish species available in the Brazilian Meridional Margin. Fisheries management, on the other hand, has remained focused on a few target species, never evolving to accommodate multiple species and fisheries. This scenario has allowed for the development of poorly controlled multispecies - multifleet fisheries, which have placed demersal stocks under pressure and made them susceptible to overfishing and local depletion. Between 2018 and 2022, a consortium formed by 19 fishery scientists from 10 research institutes addressed different aspects of this scenario, identifying the need to remodel the management system by (a) renouncing species/ stocks as the target of management and (b) raising the importance of elements that prevent degradation of marine ecosystems. Formed in the context of a governmental call for projects focused on fisheries science and management around the country, this consortium developed the conceptual and empiric foundations of a fishing management system that considers "geographic management units" and is "based on the ecosystem." This essay describes the process of critical reflection that motivated the development of a proposal for remodeling the demersal fisheries management system in the region of Southeast and South Brazil, based on fundamental aspects that could be modified given the support of scientific knowledge and national and international experiences.

Keywords: demersal fishery; Southeast and South Brazil; ecosystem-based fishery management; space-based fishery management.

RESUMO: Desde a década de 1990, a pesca demersal do Sudeste e Sul do Brasil tem se diversificado, incorporando uma ampla gama de espécies de peixes e invertebrados existentes na Margem Meridional Brasileira. O processo de ordenamento dessa atividade, por outro lado, manteve-se focado em poucas espécies-alvo e nunca evoluiu para acomodar a diversificação de espécies e pescarias. Esse cenário permitiu o desenvolvimento de uma pescaria "multiespécies – multifrotas" submetida a pouco controle, que tem mantido os recursos pressionados e suscetíveis à sobrepesca e depleções localizadas. Entre 2018 e 2022, uma rede formada por 19 pesquisadores de 10 instituições de pesquisa se debruçou sobre os diversos aspectos desse cenário, identificando a premente demanda para reformar o modelo de gestão da pesca demersal no sentido de (a) abandonar o uso de espécies/estoques como alvo da gestão, e (b) aumentar a importância dada a elementos que evitem a degradação dos ecossistemas marinhos. Reunida no âmbito de uma chamada governamental que fomentou a pesquisa científica voltada à gestão pesqueira em todo o país, essa rede de pesquisadores desenvolveu as bases conceituais e empíricas para uma gestão pesqueira baseada em "unidades geográficas de gestão" e na implementação de um manejo pesqueiro "baseado no ecossistema". Este ensaio descreve o processo de reflexão que motivou a proposta de reforma da gestão pesqueira demersal do Sudeste e Sul do Brasil, tendo, como fundamento, aspectos críticos e passíveis de mudança a partir da inserção do conhecimento científico e de experiências nacionais e internacionais.

Palavras-chave: pesca demersal; Sudeste e Sul do Brasil; manejo pesqueiro baseado no ecossistema; manejo pesqueiro espacial.

1. Introduction

Scientific counseling is an essential component in fisheries management process. In Brazil's southeast and south regions, this counseling gained momentum in the 1960s, under different formats, regularities, and varying degrees of involvement in the decision-making process. Fishery scientists were not always compelled to produce the relevant knowledge for fishery management, nor were they consistently funded for this task. Following successful experiences, such as the REVIZEE Program in the mid-1990s (MMA, 2006), in 2015, the then Ministry of Fisheries and Aquaculture (*Ministério da Pesca e Aquicultura* - MPA) took a significant step towards advancing knowledge and funding research. This was institutionalized through a joint call for projects with CNPq (MCTI/MPA/CNPq Nº 22/2015 - Ordenamento da Pesca Marinha Brasileira), creating a mechanism to induce fishery research based on the collaborative action of networks of researchers capable of:

"generating current scientific information to ensure the construction of management policies as well as the monitoring of the main species caught"; and

"supporting the fishery management process by assisting the work of the Scientific Subcommittees (SCC) and the Permanent Management Committees (CPGs) for the fishing modalities of greater economic and social importance."

This call provided an opportunity for the realization of multi-institutional projects directed toward seeking solutions for the obstacles within national fisheries management. The demersal resource fisheries in southeastern and southern Brazil constituted one of the thematic lines of the call. It required, from the projects submitted, the production of knowledge concerning the population biology of these resources (e.g., feeding, reproduction, growth, mortality, recruitment), estimations of their biomass and exploitation status, as well as their environmental interactions. Furthermore, the approved projects were expected to establish "networks" of specialized researchers with the goal of concentrating expertise and ensuring the flow of regional knowledge about fisheries resources, thus facilitating its direct application in fishery management processes under governmental authorities.

As a result of this call, the Scientific Support for Spatial and Ecosystem-based Management of Demersal Fisheries in the South and Southeast Regions of Brazil (*Subsídios Científicos para o Manejo Espacial e com Enfoque Ecossistêmico da Pesca Demersal nas Regiões Sul e Sudeste do Brasil* - MEEE PDSES) project was implemented. The project brought together 19 researchers from two fisheries research institutes, six universities, and a non-governmental organization, all with established participation in national fisheries research and specific experience in the Southeast and South regions of Brazil. Executed over five years (from January 2018 to October 2022), the MEEE PDSES project exceeded the requirements of the development, proposing, as its final outcome, a "reform" in the demersal fishery management model, breaking the paradigm of target-oriented management and formally establishing ecosystem-based spatial management in the marine environment (Perez & Sant'Ana, 2022). To achieve this, the project compiled and systematized historical fishery data, usually fragmented and available within the involved institutions, and constructed a spatial synthesis of demersal fishing. From this emerged the foundations for establishing space-based management, aligning with the country's current initiatives for Marine Spatial Planning (Gandra *et al*., 2018).

The reasons that led this network of researchers to propose this reform are justified by the long history of unsuccessful fishery management measures and the alarming state of productivity loss and environmental degradation of the demersal fishery and some of its most important stocks (e.g., Haimovici & Cardoso, 2016; Haimovici *et al.,* 2021), including the synergistic effects of ongoing ecosystem changes in the region, already noted in catch patterns (Franco *et al*., 2020; Perez & Sant'Ana, 2022; Gianelli *et al*., 2023). The identification of obstacles in the management process (e.g., escalation and concentrated action of fishing capacity) also emerged. Their solution is vital for the sustainability of the fisheries (Hilborn, 2004) and often relies minimally on the availability of in-depth biological-population knowledge.

The present analysis describes the reflective process that motivated the structuring of the MEEE PDSES project, encompassing the acknowledgment of the role of fishery management faced with the global environmental crisis, the description of the chaotic scenario in demersal fishery management in the Southeast and South regions of Brazil, and the reformative concepts that have been applied to fishery management in different regions of the planet. This essay is grounded in critical aspects susceptible to change through the integration of scientific knowledge and both national and international experiences.

2. Challenges in fishery management

> Effective fisheries management has been proven to successfully rebuild stocks and increase catches within ecosystem boundaries. Improving global fisheries management remains crucial to restore ecosystems to a healthy and productive state and protect the long-term supply of aquatic foods. (United Nations Food and Agriculture Organization, 2022, p.xvi)

Aquatic organisms captured in nature or cultivated are rich in proteins and other essential nutrients for human development and a "healthy life." Their consumption has been increasing globally, partly due to the protein demand of the growing world population. In 2019, 7% of this demand was met by fish, a rate equal to or higher than that supplied by poultry, pigs, or cattle (FAO, 2022). It is estimated that by 2050, the world's population will surpass nine billion inhabitants, and the planet will have an additional demand for 350 million tons of animal protein. Maintaining current consumption patterns implies a necessary increase in fish production equivalent to half of the current levels, which should be particularly critical in the world's poorer regions (Rice & Garcia, 2011). This perspective is at least challenging because, despite the continued increase in aquaculture production, between 40 and 50% of the fish supply comes from the sea, and this supply has remained stagnant or declined over the last three decades (Pauly & Zeller, 2016; FAO, 2022).

This trend is mainly attributed to unsustainable fishing practices (or "overfishing") that currently affect one-third of the world's marine stocks, while another 50% of them are being exploited at their maximum levels (FAO, 2022), meaning without prospects for future increases. Added to this are the effects of human activities that have altered the functioning of marine ecosystems to the extent of reducing the productive potential of major commercial stocks. More significantly, due to their global scale, climate changes caused by the accumulation of greenhouse gases have led to declines in the potential fish stock production due to progressively warmer and stratified (termed "tropicalized") oceans with lower biological production capacity, among other associated processes (e.g., deoxygenation, acidification) (Free *et al*., 2019). Overfishing, combined with global climate changes, not only affects the future food supply but also jeopardizes the livelihoods of around 520 million direct and indirect jobs and a significant portion of the economy in many countries (Allison *et al*., 2009; Sumaila *et al*., 2011).

This "perfect storm" generates, on one hand, uncertainties about the role of marine fishing in the future. On the other hand, more than ever, it reaffirms that reversing this situation requires advances in science to seek adaptive solutions and the effectiveness of fishery management processes in their implementation (Arana *et al*., 2016; Perez *et al*., 2020a). With less than 8% of global stocks considered capable of providing increased catches, reversing the overfishing condition of many stocks to more productive levels emerges as the main solution within society's reach. Although the effectiveness of fishery management is widely questioned, in several regions of the world, it has been demonstrated that this restoration is feasible (Costello *et al.,* 2016; Hilborn *et al.,* 2020). To achieve this, it is estimated that an enhancement in the effective transformation of scientific knowledge into fishery management policies, following a transparent and participatory process, is crucial, regardless of other attributes of the fisheries (Mora *et al.* 2009).

However, for the reversal of overfishing situations, management processes need to recognize and combat the main "evils" affecting the sustainability of fisheries: the escalation of fishing capacity (resulting from fishing effort and its efficiency) and "competitive" fishing (Hilborn, 2004). This has proven to be a challenging task, particularly due to significant obstacles arising from the complexity of the ecological and social systems interacting in fishery development. These obstacles were summarized in Perez *et al.* (2020a):

Productive fisheries generate increased political power, leading to more fishing capacity and added pressure on the natural environment (Ludwig *et al.,* 1993).

Objectives aimed at maximizing benefits tend to create competition among fishermen, maintaining stocks under high pressure (Hilborn, 2007).

Difficulty in achieving scientific consensus regarding the state and function of natural systems and their responses to fishing pressures (Ludwig *et al*., 1993).

Governance mechanisms tend to be deficient and weakened, mainly due to the first item mentioned above (Hanna, 1999).

Stock management measures for overfished stocks only yield benefits after a fishing restriction period. Furthermore, they may hardly benefit all involved, creating social and political resistance.

Management prioritizing target species fails to consider the importance of these species' relationships with living and non-living elements in the ecosystem. Efforts to stabilize catches may be ineffective if there are threats to the "proper functioning" of this ecosystem (Pikitch *et al*., 2004).

Failure to overcome these obstacles tends to focus fishery management on the "symptoms" presented by fisheries imbalanced with the natural environment rather than addressing the root "evils" causing these imbalances (Hilborn, 2004). For example, management actions that aim to limit catches, ensure that life cycle stages of stocks are completed in nature, or protect certain population strata considered biologically more relevant (juveniles, spawners, etc.) are common. While highly advisable as management measures, these rarely alleviate the fishing pressure on lucrative fish stock concentrations, do not prevent overfishing or even fishery collapse, and maintain fishery management in a constant state of insecurity. This state of insecurity has characterized the evolution of Brazilian marine fishing in recent decades and its management.

3. The chaos in the demersal fishery management of southeastern and southern Brazil

> Fishing authorities failed to establish timely reforms to the fisheries management system, but responded to the changing industrial fishing activities with a series of short-term measures, mostly conservation-oriented, which have more often enhanced conflicts than promoted stable (and sustainable) fishing regimes. Added to the country's general political instability, this scenario has allowed no room for predictions about the future of the fishing industry of southeastern and southern Brazil… (Patricio Arana *et al*. 2016, p.876)

Demersal fishing encompasses methods and operations aimed at capturing organisms living on or near the seafloor. In southeastern and southern Brazil, this practice formed the basis of artisanal extractive activities, evolving to an industrial scale from the 1950s (Yesaki & Bager, 1975; Freire *et al*., 2021). This process involved bottom trawling methods, initially including single and pair trawling targeting sciaenid fish (e.g., whitemouth croaker, weakfish, etc.) and subsequently double rig trawling targeting coastal shrimps (e.g., pink shrimp, seabob shrimp) (Figure 1 A-C, F), experiencing significant development during the 1960s and 1970s (Pezzuto & Mastella-Benincá, 2015). During this period, a demersal fishery management model was implemented, applied between Espírito Santo and the extreme southern part of the Brazilian Exclusive Economic Zone (EEZ), focusing on the primary resources mentioned, the so-called "controlled" resources. However, by the late 1970s and early 1980s, the overfishing state of pink shrimp and the main demersal sciaenids, such as whitemouth croaker, argentine croaker, stripped weakfish, and southern king weakfish had been characterized (Haimovici, 1998; Valentini *et al*., 2012). Furthermore, there was the collapse of fisheries directed at stocks of scallops, red porgy, and black drum (Pezzuto & Borzone, 2004; Haimovici & Cardoso, 2016). This led the Brazilian Government to implement various regulatory actions aimed at the sustainable use of controlled stocks from the 1980s. These actions included fishing bans during spawning seasons, minimum catch sizes, and control of licenses for new vessels, freezing the size of the trawler fleet at that time (Perez *et al*., 2001), and subsequently, the prohibition of catching various elasmobranchs (Vooren & Klippel, 2005; Brasil, 2014).

Despite these measures, demersal fishing in southeastern and southern Brazil expanded and diversified in the following two decades (1990s and 2000s), amplifying the use of fish and invertebrate species available in different areas and seasons. Throughout this process, trawling fisheries multiplied, with operations targeting coastal shrimps and flounders on the coast of Rio Grande do Sul (Haimovici & Mendonça, 1996); squid in the north of Santa Catarina (Perez, 2002); scampi and glass shrimps on the continental shelf of the Southeast (Perez & Pezzuto, 1998); and monkfish, argentine hake, and codling on the Southeast and South continental slope (Perez & Pezzuto, 2006; Dias & Perez, 2016). From the 1990s, the development of a large longline fishing fleet, initially targeting sharks and rays and later focusing on croakers and slope fish, was also highlighted (Vasconcellos *et al.,* 2014; Pio *et al*., 2016) (Figure 1D, H), as well as deep-set longline fishing targeting wreckfish in the southern region of Brazil (Peres & Haimovici, 1998) and grouper, sandperch, and tilefish in the southeast (Avila-da-Silva *et al.,* 2001). From 2000, deep regions of the mid-slope (500 to 1000 meters) were occupied by deep-sea trap, deep-set longline, and deep trawling operations (Figure 1G) targeting valuable concentrations of deep-sea crabs, monkfish, and deep-sea shrimps (Perez *et al.,* 2009). Furthermore, between 2003 and 2008, an unprecedented development occurred in pot fishing targeting octopus (Ávila-da-Silva *et al.,* 2014) (Figure 1G).

Subjected to little or no control, these fishing regimes progressed unpredictably, not without the concern of scientists, emphasizing the risk of concentrating a high removal capacity of these "uncontrolled" species in relatively limited spaces and time intervals, leading to overfishing processes

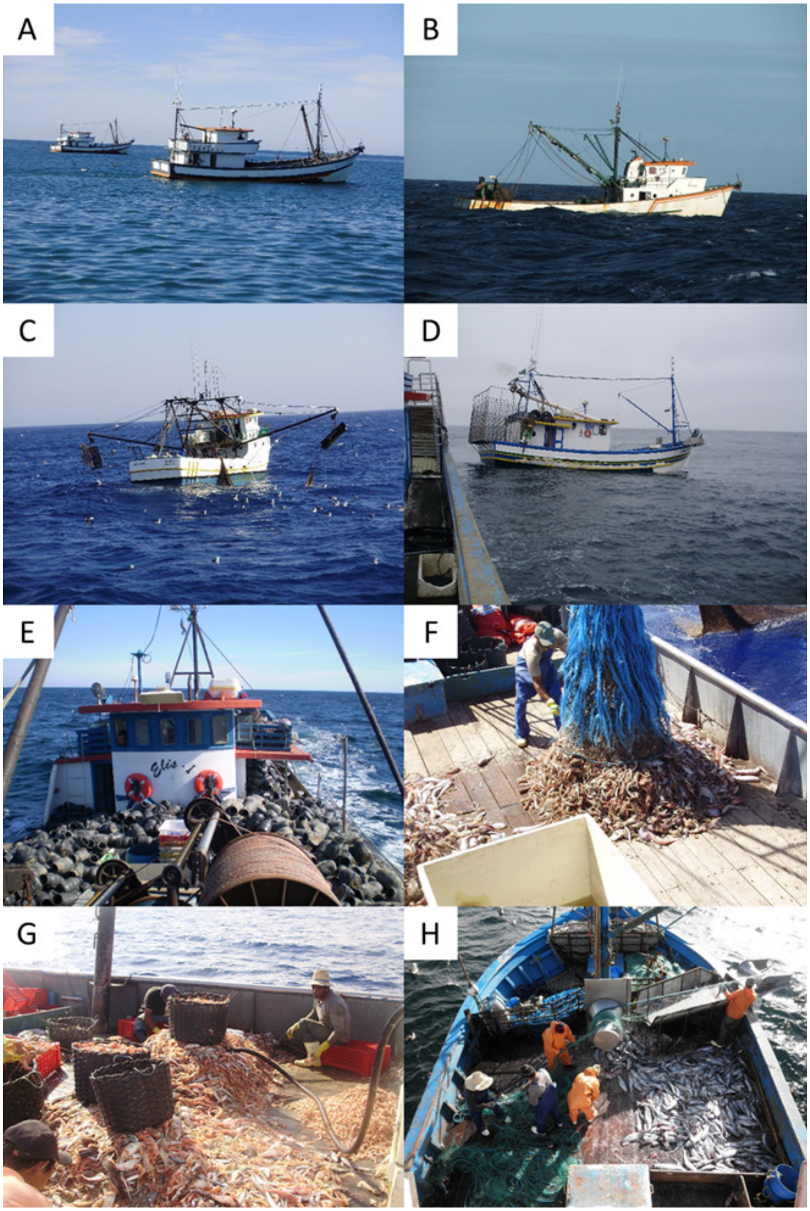

FIGURE 1 – Methods and Vessels of Industrial Demersal Fishing in southeastern and southern Brazil. A, pair trawling; B, stern trawling; C, double-rig trawling; D, gillnet fishing; E, pot fishing for octopus; F, pink shrimp catch by double-rig trawling; G, shelf-break catch with double-rig trawling; H, longline fishing catch.

SOURCE: *Projeto Subsídios Científicos para o Manejo Espacial e com Enfoque Ecossistêmico da Pesca Demersal nas regiões Sul e Sudeste do Brasil* - MEEE – PDSES – 2023. MCTI/MPA/CNPq Nº 22/2015 – *Ordenamento da Pesca Marinha Brasileira.* Final Report.

and localized depletions. These risks were eventually substantiated, as evidenced in the case of slope resources (Perez *et al.,* 2009) and the most abundant stock in the region, the whitemouth croaker (Haimovici *et al.,* 2021; Haimovici *et al*., 2022). However, these risks might have impacted numerous other stocks, historically unmonitored and never subjected to assessment processes (Dias, 2020).

The uncontrolled scenario of demersal fishing also had economic consequences. In the 2000s and 2010s, conflicts proliferated among different fisheries due to the overlapping spatial and temporal patterns of demersal fishing fleets, the low selectivity of the fishing gear used, and the competition for lucrative concentrations of species available at different times and places for various fleets. Fisheries and environmental authorities reacted to these conflicts by issuing "conciliatory" fishing management measures, for example, reviewing and creating new types of fishing permits. However, these, in practice, remained quite permissive, retaining control only for some species and legalizing the use of "uncontrolled" species, included in extensive lists of the so-called "bycatch" fauna, which could be caught, landed, and traded without any management rules (Pezzuto & Mastella-Benincá, 2015). The Interministerial Normative Instruction MPA/MMA No. 10 of June 10, 2011 (Brasil, 2011), which approved general norms and the organization of the permit system, for example, allowed holders of pink shrimp fishing permits to also catch and trade argentine red shrimp and argentine stiletto shrimp, as well as a "predictable" bycatch fauna consisting of 38 categories of fish, often encompassing various "uncontrolled" species (e.g., rays, sharks, red snappers, etc.). A new permit matrix, under discussion since 2021, brought some advancements, for instance, in recognizing multiple demersal fisheries, in some cases with spatial delimitations (e.g., "territorial sea of Rio de Janeiro"), however, still left uncertainties about management units (e.g., stocks, species, fisheries) or the species that they were allowed/not allowed to fish.

The scenario of demersal fishing management in southeastern and southern Brazil has persisted as "chaotic" despite these initiatives. This chaos is marked by a large artisanal and industrial fleet with high fishing capacity, operating across extensive areas and periods of the year. These operations occur without consistent usage rules, such as management plans, and are only subject to specific measures designed to address immediate conflicts. Adding to this scenario are biodiversity conservation initiatives launched by environmental agencies that have prohibited the capture of species under threat of extinction, classified according to criteria established by the IUCN (International Union for Conservation of Nature), the so-called "Red List" (Brasil, 2014). Focused on the conservation of individual species, this initiative has created significant obstacles to the predominantly multispecific fishing in the region, exacerbating conflicts between the government and users, with repercussions in monitoring the exploitation status of the stocks and overall environmental and fishing management.

The chaos in demersal fishing management stems from a model rooted in the development scenarios of demersal fishing from the 1960s, which was never properly modified to accommodate new resources and fisheries. This obstacle limited the reach of fishing management initiatives given the broad reaction capacity of the fishing sector and has kept demersal resources highly pressured, with environmental consequences still poorly understood

(Dias, 2020). As noted by scientists nearly two decades ago, it seems unlikely that this scenario can be reversed in the future, except through a profound restructuring of the demersal fishing management model (Rosso & Pezzuto, 2016; Perez *et al*., 2001).

As an aggravating element, it is also noteworthy that despite the extensive participation of the Brazilian state in global forums proposing the inclusion of considerations about the conservation of marine ecosystems in fishing management, these considerations have rarely been part of management measures aimed at any demersal resource in the country. Only with the development of slope fishing did ecologically focused fishing management measures begin to be proposed (see review in Perez *et al*., 2009). This gap might have been a source of obstacles to the success of demersal fishing management in southeastern and southern Brazil, given the location of fishing areas in the country's major economic centers and, as discussed below, subject to significant human actions and environmental modifications.

In this context, shifting the focus from species or stocks as the basic management units to spatial units and emphasizing elements that prevent marine ecosystem degradation, *among other things*, should be essential to a proposed reform of the demersal fishing management model in southeastern and southern Brazil.

4. The consideration of the marine ecosystem in fishery management

> Imagine "perfect" single-species management where an agency, a fleet sector or sole owner manages perfectly to maximize the single-species yield across a range of stocks. What might go wrong? (Ray Hilborn, 2011, p.236)

The notion of preserving the integrity of an aquatic ecosystem as a means to ensure the provision of fish for human consumption spans millennia. However, the so-called "traditional" fishery management widely applied during the 20th century maintained an exclusive focus on target species, the sustainability of their catches, and the maximization of their benefits (Dolan *et al*., 2016). Associated with examples of fishery collapses, this approach has often been considered ineffective and insufficient, primarily because fishing activities, along with other human activities, can alter the structure and functioning of marine ecosystems, potentially reducing their capacity to provide services to society, including the productivity of fishing resources (Pikitch *et al*., 2004).

Accordingly, for at least three decades, there has been a recognized need to expand fishery management beyond the target stock(s) to meet the demands of the different components of the ecosystems and avoid their degradation (Pikitch *et al.,* 2004). The way this evolution has materialized in fishery management processes, however, varies according to different interpretations (Morishita, 2008; Hilborn, 2011; Dolan *et al.,* 2016). In "Ecosystem-Based Fishery Management" (EBFM), the management priority shifts to the ecosystem rather than the target species (Pikitch *et al*., 2004). Ecosystem-based fishery management focuses on multiple or even all fisheries operating within an ecosystem, developing strategies that maximize joint benefits (Dolan *et al.,* 2016). In the "Ecosystem Approach to Fishery Management" (EAFM), considerations about reducing unintended mortality and disturbance of marine habitats, as well as the preservation of interactions among species, habitats, and protected species, are included in the management process directed toward the target species (Morishita, 2008; Hilborn, 2011). A more comprehensive view of both interpretations above encompasses the socioeconomic impacts of the use of marine ecosystems by fishing and other human activities. This approach has been termed "Ecosystem-Based Management" (EBM) (Curtin & Prellezo, 2010; Dolan *et al.,* 2016).

All of the interpretations above are legitimate; "some are more achievable in the short term, and others are limited by the lack of scientific knowledge, costs, or political scenarios" (Hilborn, 2011, p.235). However, it is essential to recognize that all, in some way, guide efforts to conserve the natural conditions of marine ecosystems, not just the productivity of the stocks of interest (Link & Browman, 2014). This intervention seems indispensable, as even in fisheries where the objectives related to the target stock(s) have been fully achieved, transformations in the ecosystem and its components by various agents may be underway. These alterations discreetly jeopardize the fishery's future or clash with the broader interests of society. For example, these transformations may

(a) contradict conservation policies for threatened species;

(b) be valued by public opinion as much as, or even more than, maximizing catch benefits;

(c) be effectively altering habitats, which will threaten, in the medium and long term, not only fishing but also other activities and services of societal interest (e.g., tourism); and

(d) be altering the trophic relationships in the system, causing imbalances between prey and predators and even between fisheries with different targets (Hilborn, 2011).

Despite evidence that in certain conditions, fishery management directed at the target stock(s) can be successful in achieving its objectives (Hilborn *et al*., 2020), the consideration of ecosystem components in fishery management "has become the norm rather than the exception" (Dolan *et al.,* 2016, p.1047).

The operating area of demersal fishing in southeastern and southern Brazil (Figure 2) covers about 1/5 of the Brazilian EEZ (Rossi-Wongstchowski *et al*., 2006). In relation to other maritime regions in the country, it has a high concentration of biological productivity (Ciotti *et al.,* 1995), as well as significant reserves of oil and gas (Perez *et al.,* 2020b). Therefore, it is the most economically exploited marine region and leads the national production of these resources. However, considering the significant overlap of human activities associated with the largest demographic centers in South America, it is estimated that the region accumulates almost half of the impact exerted on the entire marine environment in the country (Halpern *et al.,* 2015). The region is naturally characterized as a transition zone between the subtropical and warm-temperate zones of the Western Atlantic, hosting a wide diversity of benthic and benthopelagic fish and invertebrate species (Haimovici, 1997), which is reflected in the high number of species commercialized by demersal fishing. As seen, various fisheries using different methods in different areas and at different times share these species. Despite well-defined targets, these fisheries overlap in space-time, compete for resources, and cumulatively pressure portions of the marine megafauna communities, as well as the benthic ecosystems (Port *et al*., 2016).

In this inherently complex scenario aggravated by the lack of control of the current management model, the disadvantages of this model in relegating the conservation of benthic ecosystems to a low level of priority (or none at all) are clear. These ecosystems sustain demersal fishing and other ecosystem services, minimizing their degradation and preserving their proper functioning. The consideration of multiple fisheries that already operate on the diverse set of demersal resources, sustained by pressured benthic ecosystems on the continental margin, highlights the necessity of ecosystem-based fishery management for southeastern and southern Brazil.

5. Spatial management of fishing in southeastern and southern Brazil

> The place-based characteristics of ecosystems, natural resources, and human activities affecting them, increases the need to look at the "system" from a spatial and temporal perspective and implies that all policies and management strategies (e.g., fisheries management, marine transportation management, and marine protected area management) directed toward influencing human use of ecosystems and their resources will inherently have a spatial and temporal dimension. (Fanny Douvere, 2008, p.765)

The implementation of ecosystem-based management processes faces operational barriers (Link & Browman, 2014). In general, the concepts involved can be broad, abstract, and overly complex for managers to apply measurable and effective measures (Douvere, 2008). However, the consideration of "space" can serve as a facilitating means in this process, as populations (including fish stocks), communities, ecosystems, fisheries, and other human activities act upon the marine space, presenting a defined pattern or "spatial structure" (Crowder & Norse, 2008). Space is therefore a dimension that can integrate the components that are part of resource-use systems and other marine activities and, therefore, is a central element in the implementation of ecosystem-based management systems (Douvere, 2008). Specifically in fishery management, considering the spatial and temporal patterns of stock distribution, fishing fleets, and associated ecosystem aspects allows for the reconciliation of objectives regarding sustaining fishing activities with the conservation of resources and ecosystems (Crowder & Norse, 2008; Lauria *et al*., 2020). This process follows the logic of "Marine Spatial Planning," which, more broadly, considers the spatial interaction of all human activities with marine ecosystems, differentiating and evaluating positive and conflicting associations and guiding a decision-making process that organizes space usage and contributes to the goals of ecosystem-based management (Gilliland & Lafolley, 2008).

A starting point in using spatial management as an approach to ecosystem-based fisheries management is defining boundaries for the spatial unit within which the management will be carried out, namely, the total area in which the fishing occurs. Subsequently, objectives and priorities for this spatial unit should be defined, which, when combined with the collection of relevant spatial data for the process, results in the identification of conflicts, threats, and opportunities that should guide the management process (Gilliland & Lafolley, 2008). However, given the potential spatial diversification of ecosystems within the same fishing area, it is expected that different priorities may emerge in different spatial divisions within that area, accor-

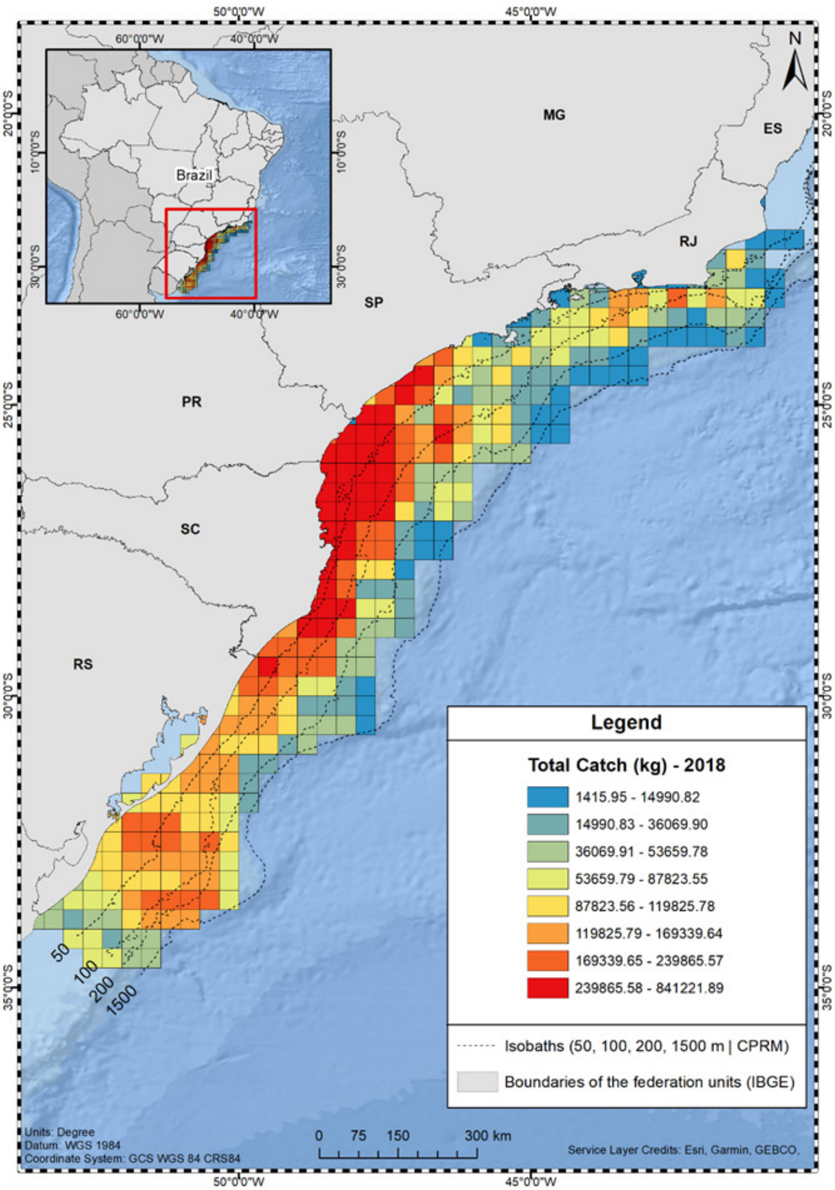

FIGURE 2 – The Brazilian Meridional Margin where the demersal fishing of the Southeast and South regions of Brazil operates. The area is divided into squares of 20 NM x 20 NM. The colors represent the landings of industrial demersal fishing in 2018.

SOURCE: Product of the *Projeto Subsídios Científicos para o Manejo Espacial e com Enfoque Ecossistêmico da Pesca Demersal nas regiões Sul e Sudeste do Brasil* - MEEE – PDSES – 2023. MCTI/MPA/CNPq Nº 22/2015 – *Ordenamento da Pesca Marinha Brasileira;* IBGE: *Instituto Brasileiro de Geografia e Estatística;* CPRM: *Companhia de Pesquisa de Recursos Minerais.*

ding to the distribution of habitats, ecosystems, biodiversity, and the economic performance of fishing fleets. The possibility of defining these divisions, within which a homogeneous scenario of the aforementioned elements is identified, suggests considering the divisions themselves as "Spatial Fishery Management Units," with the potential to restructure fishery management in regions characterized by complex fisheries, where several species are shared by different fishing methods in the same spaces (Lauria *et al*., 2020).

Spatial units as the basis for fisheries management (based on the ecosystem) therefore present themselves as a promising alternative for the intricate process of demersal fishery management in southeastern and southern Brazil. Although innovative, this alternative has been part of the regional scientific debate for over 20 years, first proposed in a meeting promoted by the Brazilian Institute of the Environment and Renewable Natural Resources (*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis* - IBAMA) focused on discussing the regulation of bottom trawling fisheries in southeastern and southern Brazil (Figure 3) (Perez *et al*., 2001). Over time, it has matured from objective analyses that revealed spatial associations among the species caught by demersal fishing (e.g., Okubo-da-Silva & Ávila-da-Silva, 2008; Rosso & Pezzuto, 2016), which served as an analytical basis for the broader study planned and executed within the scope of the MEEE PDSES project (Ávila-da-Silva & Corsso, 2022).

6. Final considerations

The arguments presented in this critical analysis form the foundational basis for the considerable challenge that constituted the formulation and implementation of the MEEE PDSES project (Perez & Sant'Ana, 2022). Interconnected with these arguments are the comprehensive parameters concerning the extensive array of data and analytical methodologies necessary not only to define spatial management units (referred to as "Geographical Management Units" – GMUs within the project) but also to characterize these units based on: fishing fleet presence, quantities landed, economic viability, fishing techniques utilized, species targeted, potential for sustainable harvesting, level of commercial stock exploitation, and the benthic ecosystem structure, pressures, and impacts. These arguments were also fundamental for a broad description of the diversity of aspects that could support the definition of the "vocations" and "potentials" of each spatial unit to accommodate demersal fishing, therefore composing a range of spatial alternatives to reorganize the demersal fishing fleet's operations in southeastern and southern Brazil.

This is understood to be the most promising, albeit challenging, alternative for an effective "shift" in the direction of sustainable use of demersal resources exploited in southeastern and southern Brazil, also proposed in other regions of the planet where fishing is equally diverse and complex (e.g., Lauria *et al*., 2020). Its complete adoption, partial adoption, or even non-adoption will depend on the extensive debate expected with society and stakeholders. Regardless of this debate, it should be understood that the conceptual and empirical

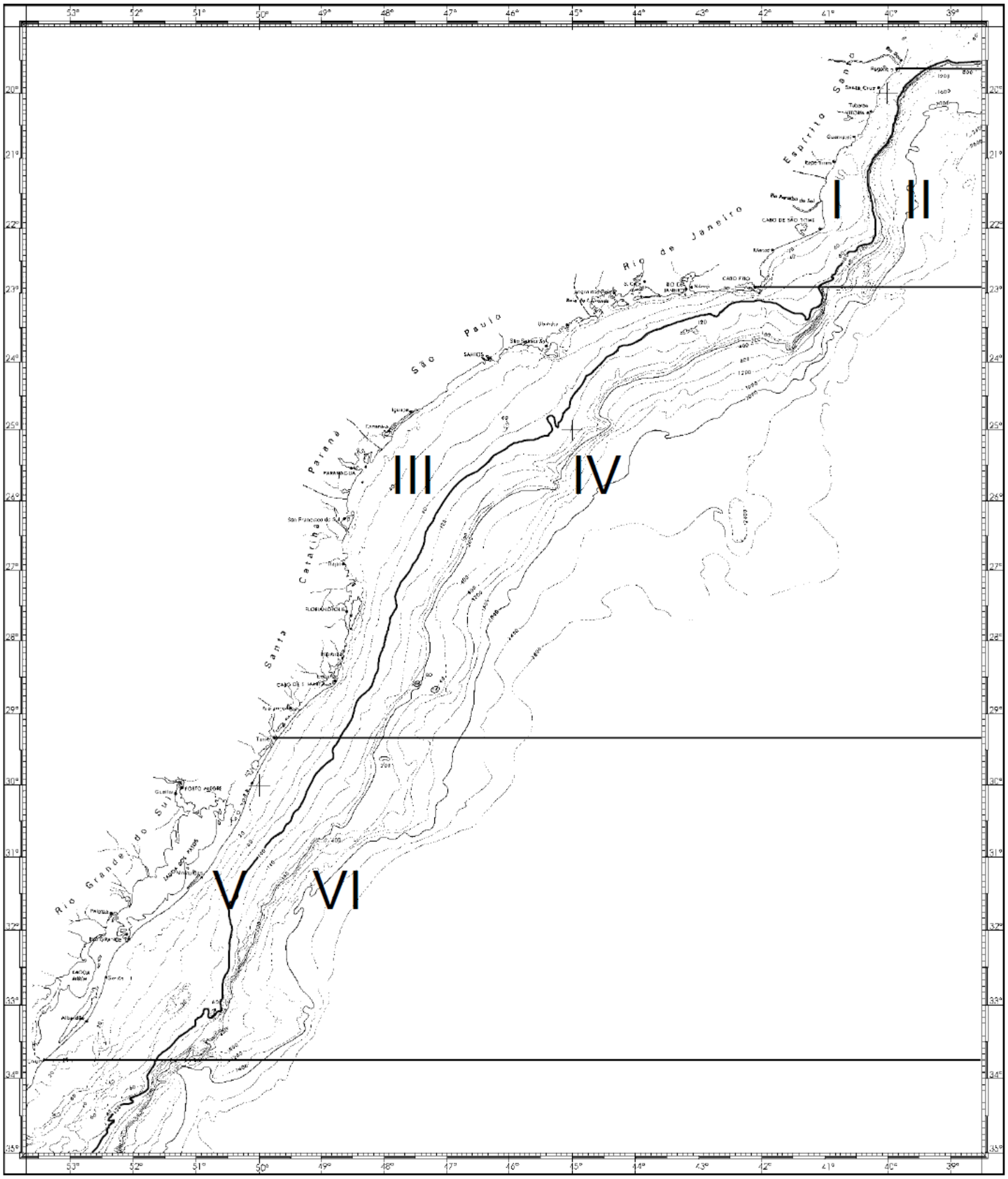

FIGURE 3 – Proposal for sectorization of trawl and gillnet fishing management in southeastern and southern Brazil.

SOURCE: Developed in 2001, during a demersal fishing regulation meeting organized by the environmental agency, *Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis* – IBAMA (reproduced from Perez *et al*., 2001).

foundations constructed in this scientific process represent, by themselves, an unprecedented body of knowledge about the demersal fishery in the region and are of great utility, irrespective of the direction taken by government authorities. Science, in any society, should be able to support innovative actions. Although changes are difficult, the network of scientists formed within the scope of the MEEE PDSES project fulfilled this role.

Acknowledgments

The *Ministério da Pesca e Aquicultura* (MPA) and the *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (CNPq) through the implementation of the MCTI/MPA/CNPq Call No. 22/2015, aimed at the Management of Brazilian Marine Fisheries, which provided full financial support for the Project "*Subsídios Científicos para o Manejo Espacial e com Enfoque Ecossistêmico da Pesca Demersal nas Regiões Sul e Sudeste do Brasil* - MEEE – PDSES" (Process: 445782/2015-3).

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