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Marine artificial reef (MAR) interference in artisanal fisheries in Brazil: use of traditional knowledge

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ABSTRACT

The aim of this study was to describe the traditional knowledge from artisanal fishermen related to marine artificial reef (MAR) ship Victory 8B and to identify possible changes in the fishery area after its installation. We performed single ethnographic interviews (n = 80) through a semistructured questionnaire, using participant observation, visual ethnography, and field diary recordings. All the interviewees were men from 27 to 77 years old, with low education levels and up to 60 years of experience in the fishery artisanal. Most of the interviewees (n = 71; 88.7%) recognize the presence of this MAR in the region and its role as a shelter for marine fauna and an attractor for species with commercial value. Even with fishery prohibition in the vicinity of MAR Victory 8B, most of the interviewees (n = 75; 93.7%) reported the practice in that area. According to the fishermen, the ship installation did not alter area the fishery, but the structure positively changed the activity by attracting more fish, increasing capture and profits. With that, from the perspective of the fishermen perception, MAR Victory 8B fulfilled its role in the enrichment of the fish stock and the conservation of marine biodiversity in the region.

Keywords: artisanal fishermen; local knowledge; submerged reefs; fishery management; southeastern Brazil.

Interferência do recife artificial marinho (RAM) na pesca artesanal do Brasil: uso de conhecimentos tradicionais

RESUMO

O objetivo deste estudo foi descrever os conhecimentos tradicionais dos pescadores artesanais relacionados ao recife artificial marinho (RAM) navio Victory 8B e identificar possíveis alterações na área de pesca após a sua instalação. Foram realizadas entrevistas etnográficas (n = 80) por meio de questionário semi-estruturado, sendo aplicado o método de observação participante e uso do diário de campo. Todos os entrevistados eram homens com idades entre 27 e 77 anos, com baixa escolaridade e até 60 anos de experiência na pesca artesanal. A maioria dos entrevistados (n = 71; 88,7%) reconhece a presença deste RAM na região, seu papel como abrigo para a fauna marinha e como atrator de espécies com valor comercial. Mesmo com a proibição da pesca nas proximidades do RAM Victory 8B, a maioria dos entrevistados (n = 75; 93,7%) relatou a prática naquela área. Segundo os pescadores, a instalação do navio não alterou a área de pesca, mas a estrutura mudou positivamente a atividade, atraindo mais peixes, aumentando a captura e os lucros. Com isso, na percepção dos pescadores, o RAM Victory 8B cumpriu seu papel no enriquecimento do estoque pesqueiro e na conservação da biodiversidade marinha da região.

Palavras-chave: pescador artesanal; conhecimento local; recifes submersos; manejo pesqueiro; sudeste do Brasil.

INTRODUCTION

The traditional knowledge part of the cultural identity and social integrity of many people, which is transmitted orally, consists of a cumulative set of knowledge, practices and representations that describe the relationships between people and the environment in which they live (Mazzo cchi, 2006; Abreu et al., 2020; Mulalap et al., 2020). Artisanal fishermen have deep local knowledge of the environment acquired during fishery operations (Murray et al., 2006; Musiello-Fernandes et al., 2020). Artisanal fisheries represent an economic activity exercised by fishermen who can perform alone or in partnerships, in which fish are caught using relatively simple gear

and less intensive and aggressive technologies (Batiste, et al., 2014; Lima et al., 2019). The production from artisanal fisheries (i.e., the fish captured and traded and used for subsistence) is relatively low.

Worldwide, fish stocks are decreasing due to human activities, such as commercial overexploitation and pollution (Amaral and Jablonski, 2005; Musiello-Fernandes et al., 2017; Abreu et al., 2020). With the aim of helping and increasing the speed of the recovery of coastal areas as well as restoring fish stocks, marine artificial reefs (MARs) are assembled around the world (Stephen et al., 1989; Lima et al., 2018). MARs are defined as structures made of rigid material, such as concrete, ship structures, tires, and oil platforms, positioned in the seabed to imitate natural reef features (Spalding et al., 2017; Vivier et al., 2021). Their surfaces provide suitable environments for the proliferation and increase of fishery biomass through the development of flora and fauna from reef environments; therefore, they are used for biodiversity maintenance (Seaman, 2000; Vivier et al., 2021). MARs work as substrates and shelters for several marine communities with ecological and economic significance, creating alternatives for artisanal fishery activities (Bohnsack and Sutherland, 1985; Lima et al., 2019; Vivier et al., 2021).

The use of MARs also has other applications. In 1989, the state of Texas (29°09'N - 94°72'W) implemented the Artificial Reefs Management Plan by installing MARs along the coast to minimize environmental and public health risks. This favored the access and use of fishery resources and their conservation (Stephen et al., 1989; Martindale et al., 2021). In 2008, the city of Massachusetts (42°32'N – 70°78'W) implemented a management plan for marine resources using MARs, promoting and developing fishery activity for small and industrial boats (Rousseau, 2008; Harrison and Rousseau, 2020). In the Algarve region, Portugal (39°30'N - 7°96'W), MARs were installed to promote underwater tourism (Whitmarsh et al., 2008; Diogo et al., 2020). In 2015, in Australia (41°17'S – 174°46'E), these structures were used to improve surfing conditions (Whitmarsh et al., 2008; Diogo et al., 2020).

In Brazil, the environmental regulatory agency 'Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis' (IBAMA) instituted the 'Instrução Normativa' (IN) N° 22 on July 3, 2009, which regulates the licensing and installation of MARs in the Brazilian Territorial Sea and Exclusive Economic Zone (IBAMA, 2009). This document specifies that the approval of MAR installation depend on artisanal fishermen's interests. In Brazil, the use of MARs is recent, but it is increasing due to the participation of research institutions and nongovernmental organizations (NGOs), with the help of environmental agencies for their implementation (Costa et al., 2014). Currently, there are several MARs along the Brazilian coast in the states of Bahia (12°52'S - 38°45'W), Rio de Janeiro (22°54'S - 43°12'W) and Paraná (25°30'S – 48°30'W) (Lima et al., 2018; 2020; Alegretti et al., 2021). They allow biomass to increase, benefiting artisanal fisheries, and create obstacles to eliminate trawling in coastal areas.

In 2003, the MAR ship Victory 8-B was assembled along the coast of the municipality of Guarapari (20°38'S - 40°27'W), in the state of Espírito Santo, Southeast Brazil. Originally from Greece, this ship was used by the merchant navy between 1975 and 1996 and is 89.7 m long and 13.6 m wide. The vessel was seized in 1997 by the customs authorities at the port of Vitória (the capital of the state) (Padilha and Henkes, 2012; Abreu et al., 2021) and became a potential pollution risk to the region after some years because of its load (Costa et al., 2014). It was donated to Guarapari in 2002 for MAR implementation, with the main goal of reducing the impacts of predatory and sport fisheries that are common around the islands in the region (Costa et al., 2014; Abreu et al., 2020). Subsequently, researchers began to observe juvenile fish from species that were thought to be extinct in the region as well as an increase in biomass and the concentration of species that were beneficial to artisanal fisheries (Abreu et al., 2020).

Although Brazilian law recognizes the importance of the participation of artisanal fishermen in the MAR installation process (IBAMA/Brasil, 2009), their involvement is still in the beginning stages. Being the group most interested in the increase in local biodiversity and the conservation of marine environments, from which they extract resources for subsistence, the traditional knowledge of artisanal fishermen must be taken into consideration, as they can contribute information about fishery areas and fishery practices (Lima et al., 2019). The relation between MARs and traditional knowledge is poorly studied (Lima et al., 2019). In this sense, the aim of the present study is to describe the relation between artisanal fishermen's knowledge about the presence of MAR Victory 8-B and to evaluate the possible changes in that fishery areas after its installation.

MATERIAL AND METHODS

Study Area

The Guarapari municipality, which has a population of approximately 128,000 people (IBGE, 2021), has approximately 1,598 fishermen and 346 vessels registered and distributed throughout the communities of 'Perocão', 'Una', 'Muquiçaba' and 'Meaípe' (Abreu et al., 2020). Its coast is composed of rocky islands, with the Three Islands, Shallow Islands and Escalvada Island being the most important habitats for reef species (Figure 1) (Floeter et al., 2007; Abreu et al., 2020, 2021). The ship Victory 8-B was designedly submerged in this area to become a MAR, thereby improving the marine ecosystem. Currently, this region shows a natural insular complex and has MARs that function as important areas for the feeding and reproduction and refuge of reef species (Costa et al., 2014; Abreu et al., 2020).

Procedures

From December 2017 to January 2018, we conducted 80 ethnographic interviews with artisanal fishermen living

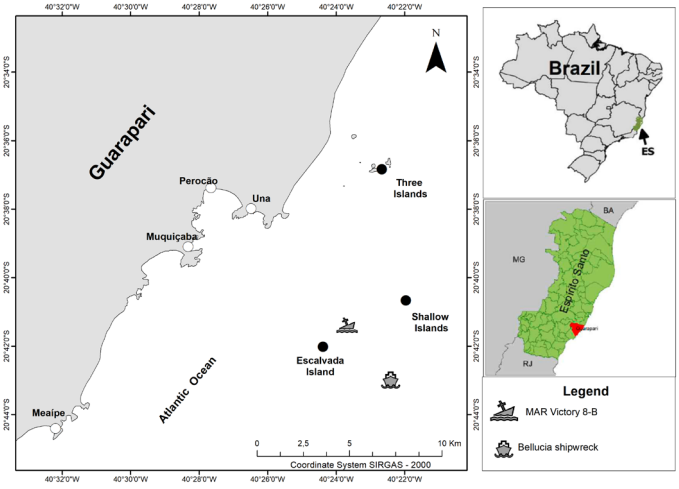

Figure 1. Location of fishing communities, coastal islands, submerged reefs in Guarapari municipality, state of Espírito Santo, Southeast Brazil.

in the municipality of Guarapari through a semistructured questionnaire containing open and closed questions (n = 52 and n = 14, respectively) (Schensul et al., 1999) to obtain data about artisanal fisheries and their relationship with MAR Victory 8-B (Chart 1). The vocabulary used in the questionnaire conformed to the common language of the fishermen to avoid misinterpretations (Zappes et al., 2016). Participant and direct observations were performed to comprehend the routines of the fishery and their associated issues, and all the data were written in a field diary (Malinowski, 2014). These methods were used for 10 hours a day for 25 days. At the moment that a fishery routine was observed without gaining new information, the researcher understood that it had reached the saturation point of participant observation, and this data collection method was interrupted.

All the interviewees received the informations about the objetives of the study, anonymity of the interview, and they were asked if would like to participate. The authorization consists of a document that clarifies the objective and purpose of the study, allowing the execution of the research in the community. This authorization was provided by the president of Fishery Colony Z-3, who is the legal representative for the community (Brasil, 2015). This study is part of a research project that was submitted to the agencies 'Brazil Plataform' and 'Sistema Nacional de Gestão do Patrimônio Genético e do Conhecimento Tradicional Associado' (National System of Genetic Patrimony Management and Associated Traditional Knowledge) (SISGEN) and authorized by the ethics committee (CAAE: 03219018.0.0000.5243) according to federal law 13,123 from 20 May 2015 (Brasil, 2015).

The sample number (n = 80) was considered suitable, as it is common to observe a repeated pattern in the answers beginning with the tenth interview, with almost no new information added after that point (Mason, 2010). Studies on traditional knowledge

Chart 1. Topics of the questions used in the semistructured questionnaire.

1. Social aspects
1.1 Sex 1.2 Age 1.3 Experience in artisanal fishery (in years) 1.4 Schooling
2. Description of fishery activities
2.1 Time spent fishery (in minutes or hours) 2.2 Time of departure to the sea 2.3 Period of year in which the fishery is operational 2.4 Fishery area 2.5 Characteristics of the boats 2.6 Gear types and Target species
3. Perceptions of the marine artificial reef (MAR)
3.1 Definition of the MAR 3.2 Occurrence of the MAR in the region 3.3 Localization of the MAR 3.4 Groups responsible for installing the MAR 3.5 Occurrence of conflict in the region near the MAR
4. Interference of the MAR in artisanal fisheries
4.1 Frequency of artisanal fisheries in the MAR region 4.2 Status of the fisheries before and after the installation of the MAR 4.3 Changes in the fishery area due to the presence of the MAR 4.4 Interference of the MAR in artisanal fisheries
5. Visual ethnograph
5.1 Localization of the fishery area before the MAR (based on the installation of the MAR) 5.2 Localization of the fishery area after the MAR 5.3 Localization of the shipwreck

have indicated that 30 to 60 interviews are enough to obtain ethnographic data from a homogeneous population (Mason, 2010).

The interviewees were selected using the following criteria: 1) they were a registered fisherman in Fishery Colony Z-3; 2) they stated artisanal fishery as their primary occupation; and, 3) they work in areas close to MAR Victory 8-B. The snowball method was used when an interviewee named another fisherman who could participate in the study (Bailey, 1982). This approach allows different insertion points in the research. This method could be interrupted at any moment, and the randomness of sampling was achieved through meetings with other fishermen (Abreu et al., 2017).

Visual ethnography is a method that uses images as a mechanism to understand the information a person has to offer; that is, through images, it creates the possibility to materialize what was not said in words (Miranda et al., 2007). This method was applied through an ethnographic map to investigate the interviewees' perceptions of 1) the status of the fishery area before the Victory 8-B shipwreck;

2) the status of the fishery area today; and 3) where the Victory 8-B is located. The ethnographic map showed landscape identifiers in the form of the main rocky islands in the municipality to support the location of the fishery areas and the MAR by the interviewees. The aim was to observe whether the fishery areas overlapped the MAR position (Albuquerque et al., 2014).

Data analysis

The reports were transcribed, and in some cases, excerpts from the interviews were used. Categories were elaborated based on pre-existing hypotheses and the objectives of the study. The following data were organized into categories related to the topics: 1) interviewee profile and brief description of their fishery activity; 2) perception of the MAR; 3) interference of the MAR in the artisanal fishery operations; and 4) location of their fishery areas. This allowed the data to be grouped by themes, leading to the classification of the reports and interpretation of the interviews (Ryan and Bernard, 2000).

All the interviews were conducted in Portuguese (the native language of the interviewer and the interviewees) in the form of dialogue, allowing interaction and the establishment of trust between the interviewer and the interviewee. In addition, all the interviews were conducted by a single interviewer (first author), who was identified as a student of a research institution known to avoid association with environmental inspection bodies or authorities by the interviewees.

A triangulation method was applied to relate the collected data with the participant and direct observations, field diary, interview questionnaire and visual ethnography to obtain the greatest understanding of the subject, comparing similarities and discrepancies among the data (Yeasmin and Rahman, 2012). The qualitative and quantitative data were integrated, supporting the issues raised in this study (Regan and Colyvan, 2000). The reports were quantified, and the percentage frequencies were described.

The interviewees answered the same questionnaire in different periods of time, and the reports were analyzed following a repeated data technique for synchronous situations (Opdenakker, 2006). The data collected from the ethnographic map were analyzed based on the indicators drawn by the interviewees. This allowed us to interpret their perception and design a map containing the MAR location and the fishery areas before and after its installation.

RESULTS

Interviewees' profiles and a brief description of the artisanal fisheries

All the interviewees were men (80) from 27 to 77 years old with low levels of education (68.8% reporting incomplete elementary school education). Despite the methods used to select the interviewees, no female fishermen were found. Experience in fisheries is up to 60 years, and the activity is practiced throughout the year. According to the interviewees, artisanal fishery is practiced along Guarapari's coast, mainly around the Three Islands, Shallow Islands and Escalvada Island, close to MAR Victory 8-B. The fishery vessels are wooden, varying from 5.5 m to 11 m long and having motors with 10 to 40 HP. Gear types include hand lines (78.79%), gillnets (16.6%), harpoons (2.2%) and fishhooks (2.2%). Some of the 80 fishermen use more than one type of gear, which explains the greater number of answers (99). The cited target species are bony fish from the families Sciaenidae, Scombridae, Tetraodontidae, Coryphaenidae, Balistidae, Carangidae, Centropomidae, Gerreidae, Sparidae, Serranidae, Carcharhinidae, Lutjanidae, Pomatomidae, Pinguipedidae and Trichiuridae.

Local perception of marine artificial reef (MAR) Victory 8-B

Most of the respondents (88.7%) recognized the presence of MAR Victory 8-B in the region and described another ship close to Guarapari's coast called Bellucia, which accidentally sank in 1903. Nine fishermen (11.2%) did not report the presence of Victory 8-B. These sunken vessels are referred to by the fishermen as 'Victory 8-B' and 'Bellucia', 'ships', 'shallow islands', 'fishery zones', 'reefs', 'abrolhos' and 'three islands'. They reported that the Victory 8-B is located 'between the Shallow Islands and Escalvada Island' (86.2%) or 'close to the Escalvada Island' (3.7%), while Bellucia is 'close to the Shallow Islands' (87.5%). Bellucia also attracts sea life, functioning as a MAR even though its submersion was unintentional.

The interviewees reported several different groups responsible for the installation of MAR Victory 8-B installation (Table 1). The Bellucia shipwreck occurred accidentally, when the vessel crashed into the Shallow Islands and sunk. The Victory 8-B is used for artisanal fishery activities, diving and tourism, serving as a feeding area and a refuge for fish. According to 78 (97.5%) of the fishermen, this MAR shelters marine fauna. Only two of the fishermen (2.5%) did not know this was a use for the MARs. According to the fishermen, the permanence of fish species in the MAR is mostly due to food availability (41.2%) and the presence of reefs (16.2%) (Table 2).

Most of the fishermen (67.5%) reported that the Victory 8-B wreck occurred as part of a plan to create a MAR that could 1) promote touristic diving, 2) increase artisanal and sport fisheries, 3) grow reefs and attract fish, creating a fishery zone, and 4) be a reference point for fisheries and diving. Some of the fishermen (32.5%) reported that the intentional shipwrecking happened only because the vessel was old, scrapped, docked at the port of Vitória and unable to navigate the ocean again. The interviewees also described some conflicts about the use of the area, mainly between artisanal fishermen and divers (Table 3), as seen in the report below:

"*The dives occur mainly on the weekends when the area is full of tourists. They rent boats and go fishery near to the MAR Victory, and*

Table 1. Groups that are responsible for the installation of the Victory 8-B marine artificial reef (MAR) according to artisanal fishermen in Guarapari municipality, state of Espírito Santo, Southeast Brazil.

Responsible groups	Number of reports	%
Does not know	21	26.2
Diving companies from Guarapari	15	18.7
Brazilian Navy	12	15.0
Companies from Vitória	11	13.7
The state of Espírito Santo	8	10.0
Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA)	3	3.7
The city of Vitória	2	2.5
Petrobras	1	1.3
Fishery Colony Z-3	1	1.3
Guarapari municipality	1	1.3
Did not answer	5	6.3
Total	80	100

Table 2. Reasons for the permanence of fish species near MAR Victory 8-B according to artisanal fishermen in Guarapari municipality, state of Espírito Santo, Southeast Brazil.

Reason	Number of reports	%
Food availability	33	41.2
Presence of reefs	13	16.2
Refuge and food availability	12	15.0
Refuge	10	12.5
Reproduction area	9	11.3
Did not answer	2	2.5
'Presence of life'	1	1.3
Total	80	100

Table 3. Conflicts related to the use of the area around MAR Victory 8-B according to fishermen in Guarapari municipality, state of Espírito Santo, Southeast Brazil.

Cause of conflict	Number of reports	%
Fishermen x divers (harpoon fishery and tourism)	22	27.5
There is no conflict	16	20.0
Small boat fishermen x trawler fishermen	8	10.0
Does not know	8	10.0
Petrobras	6	7.5
Inspection	6	7.5
Samarco Mining Company	3	3.7
Brazilian Navy	1	1.3
Artisanal fishermen x artisanal fishermen	1	1.3
Did not answer	9	11.2
Total	80	100

Table 4. Frequency of artisanal fishery practices around marine artificial reef (MAR) Victory 8-B, Guarapari municipality, state of Espírito Santo, Southeast Brazil.

Time scale	Number of reports	%
Daily	24	30.0
Monthly	21	26.2
Occasionally	19	23.7
Does not fish around MAR	9	11.2
Rarely	3	3.8
Did not answer	3	3.8
Does not know	1	1.3
Total	80	100

sometimes they fish more than we do. They have no control and do not take only what is necessary and end up having conflicts with us."

Report of fishermen in relation to the conflicts in the fishery area.

Interference of marine artificial reef (MAR) Victory 8-B in the artisanal fisheries

Most fishermen (93.7%) said that they work around Victory 8-B, with 24 (30%) fishing in the area of the MAR daily (Table 4). Sixty of the fishermen (87.5%) reported that there is interference from the MAR in the artisanal fishery operation, mainly related to the increase in the fish catch around the MAR (77.5%) (Figure 2).

Before the MAR installation, the fishery status was classified as 'bad' (40%), but 55 fishermen (68.7%) reported that fishery activity improved after its installation, generating a feeling of satisfaction among them (Figure 3). The main fish species that occurred previously in the region were bony fish, such as 'badejo' (*Mycteroperca bonaci*), 'olho de boi' (*Seriola lalandi*), 'chicharro' (*Trachurus lathami*), 'sarda' (*Sarda sarda*), 'garoupa' (*Epinephelus marginatus*), 'cioba' (*Lutjanus chrysurus*), 'mero' (*Epinephelus itajara*), 'peroá' (*Balistes vetula*), 'corvina' (*Micropogonias furnieri*), 'pescadinha' (*Macrodon ancylodon*),

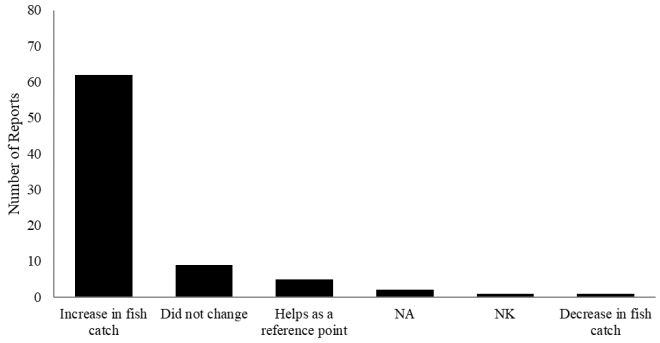

Figure 2. Interference of marine artificial reef (MAR) Victory 8-B in artisanal fishery practices, according to artisanal fishermen in Guarapari municipality, state of Espírito Santo, Southeast Brazil. NA, did not answer; NK, does not know.

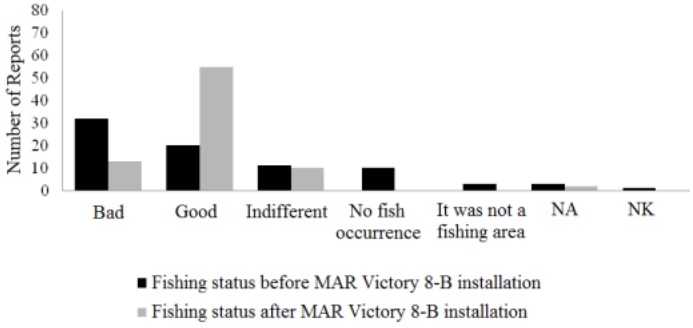

Figure 3. Fishermen's perceptions of the status of artisanal fisheries before and after the implementation of marine artificial reef (MAR) Victory 8-B in Guarapari municipality, state of Espírito Santo, Southeast Brazil. NA, did not answer; NK, does not know.

'dentão' (*Lutjanus jocu*), 'enchova' (*Pomatomus saltatrix)*, 'pescada' (*Cynoscion* sp.*)*, 'espada' (*Trichiurus lepturus*), 'pargo' (*Lutjanus purpureus*), and 'cavala' (*Scomberomorus cavalla*); cartilaginous fish, such as sharks and rays; and marine mammals, such as dolphins. According to the interviewees, there was an increase in the number of individuals of these species after the installation of Victory 8-B.

Sixty-nine fishermen (86.2%) affirmed that the fishery area had not changed with the installation of the MAR, indicating that it remained the same with and without the presence of the MAR. Eleven fishermen (13.1%) reported that the area in the vicinity of the ship changed (Figure 4).

When we questioned the interviewees about what could be done to improve fishery activity in the region even after the MAR installation, they mainly suggested the prohibition of trawlers for artisanal fisheries (33.7%), more efficient inspections by the responsible agencies (20.2%) and the installation of more MARs created by sunken ships (15.7%) (Table 5). Each fisherman (80) suggested one or more actions, which justifies the higher number of answers (89).

DISCUSSION

Interviewees profiles and a brief description of artisanal fisheries

On the coast of the municipality of Guarapari, artisanal fishery activities are practiced mainly by men with low levels of education and high economic dependency on fishery (Abreu et al., 2020). This scenario is common along the Brazilian coast, influencing the quality of life of the families involved in this artisanal fishery (Maruyama et al., 2009; Zappes et al., 2016; Musiello-Fernandes et al., 2017; Abreu et al., 2020). Women are considered the main actors in sustainable development due to their inclusion and collaboration in domestic and community activities, for example, taking care of children, making food, cleaning the domestic environment, and cleaning the fish to be marketed, which consequently helps in the maintenance of local culture in a healthy way (Zappes et al., 2016).

The interviewees reported that artisanal fishery is practiced mainly in the vicinity of natural coastal islands and around MAR Victory 8-B and Bellucia shipwreck. This zone has high biodiversity, which attracts fishermen because they can optimize the fisheries for their subsistence and commercialization (Costa et al., 2014; Lima et al., 2019). Small boats are favored for their ability to navigate close to the seashore but have limitations for fishery autonomy, as they cannot stay in operation for long periods (Lima et al., 2019). The gear choice depends on the target species, and the most used is the hand line. It has a low operational cost and is easy to handle in areas close to MARs and rocky seabeds; it also allows the fishermen to be more selective, resulting in less material discard, which reduces degradation and pollution in the ecosystem (Martins et al., 2009). In general, the region presents small-scale fishery activities performed by artisanal fishermen distributed in small communities with minimal government intervention (Martins et al., 2009). Moreover, communities are located 60 km from large cities, which limits access to larger business centers (to better commercialize fish), public transportation, recreation, health care and education, all of which are basic services for better quality of life. These are identified as important factors in fishery societies in the state of Espírito Santo.

Local perceptions of marine artificial reef (MAR) Victory 8-B

The use of shipwrecks and rigid structures to create MARs and improve artisanal fishery operations and diving and touristic activities, control beach erosion and preserve protected areas is becoming more frequent (Jayanthi et al., 2019; Folpp et al., 2020). MARs are a fishery management tool, as they provides a new substrate for fish feeding and become a concentrated area for target species; moreover, MARs reduce the impact of

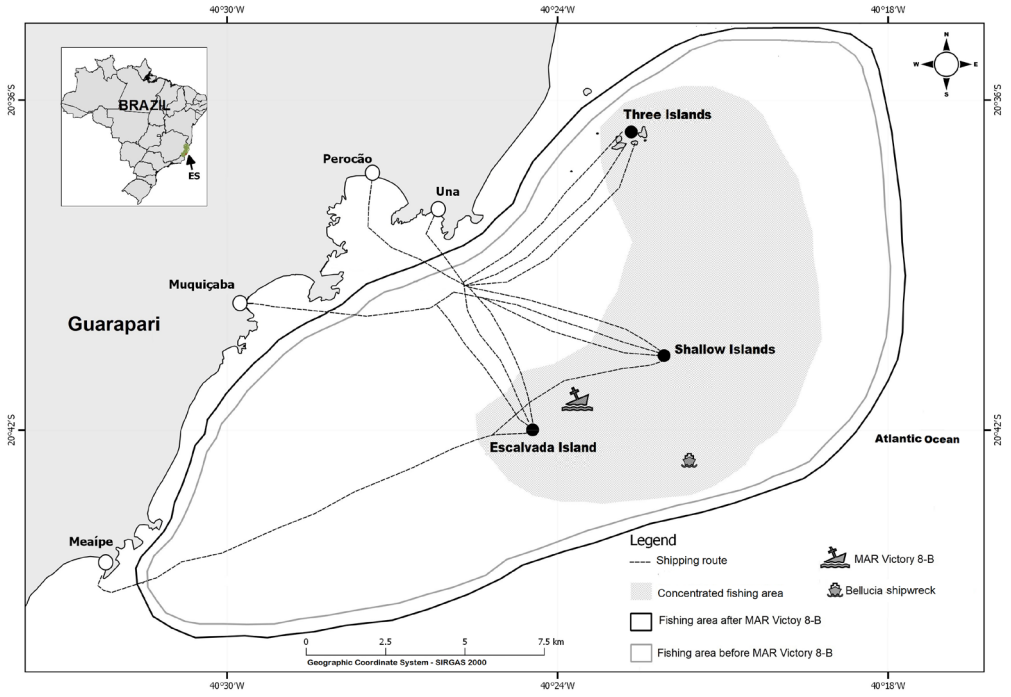

Figure 4. Comparison of the artisanal fishery area before and after the installation of the marine artificial reef (MAR) Victory 8-B according to the reports of fishermen in Guarapari municipality, state of Espírito Santo, Southeast Brazil.

predatory fishery activities in coastal zones (Seixas et al., 2013; Toleto et al., 2020). In the study area, the interviewed fishermen affirmed that MAR Victory 8-B was intentionally shipwrecked to promote touristic diving in the region and to improve artisanal and sport fishery activities. The fishermen also recognized that the unintentional sinking of the Bellucia turned it into a MAR and that there was an increase in fishery activity after the Victory 8-B installation. This increase is related to the quantity (kilos) of fish caught per day by artisanal fishermen because, after installing the MAR, they spent less time at sea and captured a greater amount of fish. As MAR Victory 8-B is located relatively close to the coast, industrial fisheries do not have access to this area and therefore do not hinder artisanal fishery activity. In this way, the use of MARs close to the coast can be an effective management tool for preventing the invasion of industrial fisheries into artisanal fishery territories.

Usually, MARs are assembled where fishery attractions receive public attention (Abreu et al., 2021). The entire Victory 8-B installation process was conducted by the 'Secretaria de Estado de Meio Ambiente e Recursos Hídricos do estado do Espírito Santo' (Secretary of State for the Environment and Water Resources of the state of Espírito Santo) and approved by the Brazilian Navy Port Captaincy to ensure navigational safety in the region (Costa et al., 2014; Abreu et al., 2020).

A lack of communication can cause discontentment among communities, complicating the dialogue about questions that involve environmental conservation processes (Abreu

Table 5. Actions to improve artisanal fishery operations according to fishermen in the municipality of Guarapari, state of Espírito Santo, Southeast Brazil.

Action	Number of reports	%
Trawler prohibition for artisanal fisheries in the area	30	33.7
More efficient inspection by responsible agencies	18	20.2
Installation of more MARs from sunken ships	14	15.7
Fishermen education about closed fishery seasons	12	13.5
Prohibition of diving for sport fishery	6	6.7
Partnership between private companies and the fishery colony	4	4.5
Decrease coast degradation by urban occupation	2	2.3
Pier construction in Perocão Beach due to the difficulties in docking boats	2	2.3
Allow artisanal fishery activities in the precise location of MAR Victory 8-B	1	1.1
Total	89	100

et al., 2017; Musiello-Fernandes et al., 2017). In the present study, the fishermen's limited knowledge about the groups responsible for the MAR installation and its final goals reveals a scenario that is likely to induce conflict. This perception results from the lack of incorporation of the fishery community by environmental agencies.

For the installation of structures that may interfere in marine ecosystems and, as a consequence, artisanal fisheries, there must be stakeholder participation starting in the early stages of the process to facilitate information interchange among all the groups involved (Ravesteijn et al., 2014; Carral et al., 2018; Lima et al., 2019; Espinoza et al., 2020). Fishermen can feel excluded from decisions that involve their territory (Musiello-Fernandes et al., 2017). This feeling is intensified by the lack of interest that public agencies have in incorporating them in the decision-making process.

Before the installation of the MAR Victory 8-B, the region already sheltered some bony and cartilaginous fish species of economic importance; however, according to the interviewees, the fish populations increased after the placement of the MAR. A MAR can provide refuge and food for fish, for example, as a result of resource concentrations that were previously dispersed throughout the environment (Pickering and Whitmarsh, 1996; Abreu et al., 2020). Artisanal fishermen have detailed knowledge about the species they catch, mainly about their habitats and feeding habits (Lima et al., 2018). This justifies their detailed perception of the MAR as a refuge and feeding zone for local target species.

In this study, the interviewees highlighted conflicts between the fisheries and small boats, divers (fishers and tourists that practice harpoon fishing) and trawlers due to the interest in the area around MAR Victory 8-B. Diving activity is illegally practiced by artisanal fishermen and by registered divers from tourism companies (Seaman and Sprague, 1991; Abreu et al., 2021). However, some of the divers from tourism companies take advantage of their licenses to practice indiscriminate harpoon fishery around MARs with their own equipment (Abreu et al., 2021). Both groups agree with MAR implementation, but divers are opposed to the use of MARs by artisanal fishery operations due to personal interests in using the area only for their activities.

Studies in the Indian and Pacific Oceans highlight the conflicts between artisanal and industrial fisheries related to the worldwide fishery sector (Bavinck, 2001; Truchet and Noceti, 2021). Globally, the industrial fishery fleet is responsible for the largest annual catch, and in the South and Southeast Brazilian regions, trawling is the main fishing mode responsible for demersal catches (FAO, 2012; Musiello-Fernandes et al., 2017). In the region of Guarapari, there are conflicts between small-scale and trawl fisheries. The interviewees questioned the environmental sustainability of trawl fisheries, mainly because it has a poor ability to selectively catch fish and produces large amounts of bycatch and discards. Many environmental impacts occur as a result of navigational operations of industrial fisheries, such as natural stock biomass reduction, habitat degradation through contact with fishery equipment in the seabed, fossil fuel use and greenhouse gas emissions (Lima et al., 2018).

The territories of the fishermen in Guarapari have been informally delimited, and part of the territory has already been lost. Nevertheless, the fishermen resist, as they depend on small-scale fishery areas and have values associated with and bonds to the zone. In contrast, industrial fisheries have resources to explore larger and more distant areas, and they have received fewer penalties than artisanal fisheries, which are more limited by equipment and techniques (Abreu et al., 2020). According to the fishermen in regions where communities depend on fishery activities, policing must: 1) be focused on large fishery vessels from other states; 2) establish and delimit fishery areas only for artisanal fisheries, as defined with the stakeholders; and 3) execute actions that are compatible with the interests of all social groups.

Interference of marine artificial reef (MAR) Victory 8-B in artisanal fisheries

In Brazil, fishery operations are prohibited near MARs according to law, and each regional environmental institute is responsible for defining the areas in which fishery operations are restricted (IBAMA/Brasil, 2009). In the case of MAR Victory 8-B, the legislation does not define the restricted area and unofficial documents from non-governmental organizations suggests that artisanal fishery operations can be conducted at a distance of 150 meters from the structure. Communities with low levels of education are often only informed about certain legislation, while its terms and language are inaccessible to local actors (Milanez, 2015; Abreu et al., 2017). Another issue is the way the law was written, as most of the time, legislation is formed from the top down; that is, the orders are defined by public managers and the affected population does not participate in the discussions on the subject. Environmental inspection in the studied area and around the country remains the responsibility of IBAMA, an agency from the 'Ministério do Meio Ambiente' (MMA; Ministry of the Environment). Fishermen do not have a good relationship with this organization, as its image is linked to the application of fines and penalties to those who break laws, that is, it is a relationship of power and hierarchy (Musiello-Fernandes et al., 2017; Abreu et al., 2020).

The interference of MAR Victory 8-B in artisanal fisheries is positively perceived by the interviewees, as they affirmed that there was an increase in fish quantity in the region. From an ecological point of view, this increase is related to: 1) the emergence of more complex habitats; 2) a higher exposition gradient (wave action and water movement) and 3) higher nutrient concentration in the area around the MAR, allowing the colonization and establishment of different ecological communities (Costa et al., 2014; Abreu et al., 2020; Cardoso et al., 2020; Hylkema et al., 2021). The Victory 8-B, similar to other MARs, offers a suitable environment for the maintenance and enrichment of the local trophic web, redistributing species according to their food webs and increasing the densities of the populations. This benefits local

fishery activities and reduces eventual conflicts due to the overlap of different groups in the fishery area.

Before the installation of MAR Victory 8-B, the fishermen considered their activity status 'bad' due to the low fish catch. According to the fishermen, after its installation, fish quantity increased, generating a feeling of satisfaction related to the ship. Studies in Brazil, Mexico, Italy and China have shown the potential of MARs for increased fish population decreases and enriching fish stocks, even with species that were considered locally extinct (Scarcella et al., 2015; Wang et al., 2015; Lima et al., 2018). In Guarapari, artisanal fishery boats have low autonomy and no capacity to keep fish catch aboard for a long time. Moreover, there are no appropriate docking ports, so there is still much improvisation in this regard. All these questions reflects the lack of public and private investment in the local fishery sector.

The coastal area used by artisanal fishery vessels remained the same after MAR Victory 8-B was installed. According to fishermen, the accidentally sunk Bellucia and natural reefs were already present and were known to attract target species. However, fishery production increased after the installation of the MAR, indicating that the attraction of fish to the area was amplified. This indicates that the primary goal of the MAR, to improve the fish stock in the region (Lima et al., 2018, 2019), was successfully achieved.

Given the presence of 'Three Islands', 'Shallow Islands', 'Escalvada Island', MAR Victory 8-B and the 'Bellucia' wreck, the Guarapari coast functions as a reef complex. A reef complex is defined as a set of submerged reefs with high structural diversity, including fringes, parcels, pinnacles, bank reefs, and oval areas, and associated bioconstruction and 'buracas' (Leão et al., 2003; Abreu et al., 2020). The same concept can be applied to the studied region, as it is formed by an island complex and MARs (Leão et al., 2003; Abreu et al., 2020). The zone offers fishery areas close to the coastline, which minimizes the displacement of fishermen and the costs involved in fishery activities.

The region needs management to regulate fishery operations, diving and tourism activities and urbanization as well as inspection strategies to maintain the local quality of life and environmental sustainability (NRC, 1993; Musiello-Fernandes et al., 2020). Therefore, we presented management proposals to improve artisanal fishery operations in MAR areas in Chart 2. In general, these proposals reflect the needs of the fishermen for more government investments in the fishery sector and qualifications and incentives for cooperation. Such investments could facilitate the implementation of actions that lead to sustainable solutions, including not only the conservation of ecosystems but also the strengthening of cultural identity and diversity, especially for future generations.

Chart 2. Proposals for artisanal fishery management with the possibility of implementation in different fishery zones with marine artificial reefs (MARs).

Action	Actors
1) Promoting a dialogue between local actors and public agencies avoiding a top-down regulatory system.	Fishery colonies, educational and research institutes in the region, and municipal government.
2) Developing an understanding of the local cultural patterns and identifying local actors who can serve as interlocutors.	Non-governmental organizations, fishery colonies, and educational and research institutes in the region.
3) Developing MARs for the benefit of social marketing, and the informal/oral transmission of this information among fishermen.	Non-governmental organizations, educational and research institutes in the region, municipal government, and fishery colonies.
4) Promoting joint educational programs in order to discuss laws, use and MAR installation using a local vocabulary.	Non-governmental organizations and educational and research institutes in the region.
5) Establishing new MAR areas from previous experiences with unusable vessels. There must be a guarantee for the participation of stakeholders in the decision-making process.	Non-governmental organizations, educational and research institutes in the region, environmental management agencies, and fishery colonies.
6) Elaborating joint actions with universities, community and government in order to assure the maintenance of MARs and the artisanal fisheries.	Non-governmental organizations, fishery colonies, educational and research institutes in the region, and environmental management agencies.
7) Disclosing results from scientific studies related to the fishery with the local communities.	Non-governmental organizations and educational and research institutes in the region.
8) Developing regular educational campaigns about importance of the closed season as a public policy of general interest.	Non-governmental organizations, environmental management agencies, fishery colonies, and educational and research institutes in the region.
9) Intensifying inspections by environmental agencies in order to avoid irregular fishery.	Environmental management agencies.

CONCLUSION

Marine artificial reefs (MARs) play an important role in fishery planning and management, as they can represent a new type of substrate for fish reproduction, refuge and feeding, concentrating target species and directly benefiting fisheries. The artisanal fishermen in the Guarapari municipality recognize the presence of MAR Victory 8-B as being related to those functions. Its implementation has had positive influences on local fishery operations, allowing fish catches and the conservation of marine biodiversity in the region.

Even though the area used remained the same after the installation of the MAR Victory 8-B MAR, interviewees reported that there was an increase in catch volume. The limitation of the fishery area to zones with high fish concentrations leads to the reduction in operational costs and, consequently, more profit. Therefore, with traditional knowledge, we can affirm that MAR installation enriches the environment and improves artisanal fisheries, which increases family incomes and quality of life. With the results of the present study, we propose management and planning actions that can be implemented in other areas with MARs and artisanal fishery activities.

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Conflict of interests

Nothing to declare.

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Authors' Contributions

Abreu, J.S.: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. Di Beneditto, A.P.M.: Funding acquisition, Investigation, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing.Martins, A.S.: Investigation, Validation, Writing – original draft, Writing – review & editing. Zappes, C.A.: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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