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Zoning Design for the Protected Conservation Area of Pinang, Siumat and Simanaha Waters (PISISI) in Simeulue District, Aceh

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Abstract: Simeulue District has several conservation areas, including the Pinang, Siumat, Simanaha (PISISI) marine conservation area. To maximize the management of the marine protected area (MPA) of PISISI, which has been reserved by the Government of Aceh, it is necessary to analyze the management and zoning plan, especially in determining the location of the core zone (no-take zone). The core zone determination is the most important part in planning to protect coastal areas as a manifestation of sustainable management of fish resources and the environment. The research purpose is to determine the location of the no-take zone based on conservation targets that have high biodiversity value, analyze the optimum size of the no-take zone, and determine the zoning design in the MPA of PISISI, Simeulue District. Therefore, the Marxan model was used in this study, which is the most widely used MRA zoning design and planning tool. However, Marxan was unable to determine the priority location of conservation areas and the optimum size of the no-take zone. For this reason, a combination of Marxan and the MPA Size Optimization Tool was used. The study at the MPA of PISISI is an example of how the information generated by these two tools becomes a reference or a model that will be applied to other MRAs that have not yet compiled a zoning plan. The zoning results lead to a no-take zone proposal divided into eight sections with a size of 3 km which was obtained from the consideration of the home ranges of 55 high-economic fish species found in the MPA of PISISI. Based on the results of the analysis of the two instruments, the proposed core zone area is 5.14%, which meets the requirements of Marine and Fisheries Ministerial Regulation Number 30 Year 2010 stating that each marine conservation area must have a core zone with an area of at least 2% of the total area.

Keywords: marine conservation areas, Marxan model, MPA Size Optimization Tool, core zone, no-take zone.

亚齐西穆卢区皮南，苏马特和西马尼亚哈水域保护区（PISISI）的分区设计

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摘要：西穆卢区有几个保护区，包括槟城，苏马特，西马那哈（皮西西）海洋保护区。为了最大限度地管理亚齐政府保留的皮西西海洋保护区（MPA），有必要分析管理和分区计划，尤其是在确定核心区（禁区）的位置时。确定核心区域是规划保护沿海地区最重要的部分，这是对鱼类资源和环境进行可持续管理的体现。研究目的是根据具有高度生物多样性价值的保护目标确定禁区的位置，分析禁忌区的最佳大小，并确定锡穆卢埃区皮西西 MPA 的分区设计。因此，本研究中使用了马克思主义模型，这是最广泛使用的 MRA 分区设计和规划工具。但是，马克思无法确定保护区的优先位置和禁区的最佳规模。因此，结合使用了马克思主义和 MPA 尺寸优化工具。皮西西 MPA 上的研究是一个示例，说明了这两种工具生成的信息如何成为参考或模型，该模型将应用于尚未编制分区计划的其他 MRA。分区结果导致了一个不带区建议，该区分为三个部分，大小为 3 公里，这是考虑到皮西西 MPA 中发现的 55 种高经济鱼类的家园范围而得出的。根据这两种工具的分析结果，拟议的核心区面积为 5.14%，符合 2010 年第 30 号海洋和渔业部级法规》的要求，该法规规定每个海洋保护区必须有一个核心区，面积为至少占总面积的 2%。

关键词：海洋保护区，马克思模型，MPA 尺寸优化工具，核心区，禁区.

1. Introduction

The Indonesian Government's commitment to establishing 20 million hectares of marine protected area (MPA) throughout Indonesia by 2020 was presented by the President of the Republic of Indonesia at the World Ocean Conference (WOC) event in Manado in 2009. At the 2018 Our Ocean Conference in Bali, the Ministry of Marine and Fisheries will continue to increase marine conservation area to 30 million hectares by 2030.

In Aceh, the Qanun (Law) of Zoning Plan for Coastal and Small Island (RZWP3K) Aceh states that Simeulue District has four MPAs, namely, South Teupah MPA, West Simeulue MPA, Central Simeulue MPA, Simeulue Cut and Salang, and Pinang, Siumat, and Simanaha (PISISI) MPA. The decision of the Regent of Simeulue under No. 523/340/2014 announced the Establishment of the PISISI Conservation Area Management Board with an area of 44,404.10 ha.

In the MPA of PISISI area, most people are fishermen who use the waters to find fish, fish farming, sea transport, and marine tourism [1]. The high level of exploitation by the community is believed to disrupt biodiversity and ecosystem resources because the potential threat will always exist where people exploit these resources for the survival of their lives [2]. Furthermore, small-scale fisheries are also an important part of coastal communities' economy, in this case, traditional fishermen. Small-scale fishing is an alternative employment opportunity [3] and an integral part of coastal culture [4].

Conservation areas of PISISI are extensively large; therefore, it needs to have a high selectivity method and is effective in determining the catch zone and/or core zone [1]. To optimize the proposed MPA of PISISI, it is necessary to have strategies integrated into the management plan in particular to determine the catch zone or core zone. Determining the core zone or catch zone is the most important part of planning to protect coastal areas as sustainable governance of fisheries resources. The MPA of PISISI is one of the MPAs that already has ecological data surveyed by Fauna & Flora International (FFI), so it is more ready to be managed than other MPAs in Simeulue District.

Efforts that need to be made to minimize threats to coastal ecosystems are to place the MPA in the right location [5]. For MPAs to be managed effectively, the Government also recommends to provide many benefits such as increasing size, abundance, diversity, and biomass of fish [6, 7], increasing fishery stocks through scattered larvae [8, 9] as well as an increase in coral reef capabilities to recover [10, 11]. Currently, the MPA is one of the most effective methods used when resources are limited, and the pressure on coastal ecosystems is beginning to concern. Furthermore, the MPA is also created as a strategy to restore small-scale fisheries to increase production outcomes in the medium to long term [12] and to restore fish populations [13].

Systematic conservation planning is one of the approaches used to design a conservation area that meets biodiversity targets [14, 15]. The application of this approach in practice is supported by many software packages, one of which is Marxan (Marine Reserve Design Using Spatially Explicit Annealing). This suite of tools has been used in more than 180 countries to design conservation areas both on land and at sea [16], including Indonesia [17, 18]. Marxan is the most widely used planning software for conservation area zoning design in the world [19]. Marxan-based geospatial information system is recognized and trusted to design zoning based on conservation criteria according to its allocation. Marxan is also used as a decision support tool that can provide several zoning options for biodiversity conservation and minimize negative social impacts by accommodating socio-economic aspects. Marxan has also been used to design conservation areas in Marine Parks in Europe [12] and Indonesia [20].

Marxan is one of the supporting tools in determining the core zone. Marxan contributes to the MPA managing agency intending to find out which sites are suitable and comply with the objectives of the management area. However, in practice, sometimes area designers still have difficulty determining the ideal size and area in a conservation area that complies with the characteristics of the available resources [21]. The No Take Zone Size Optimization Model (MPA Size Optimization Tool) is a recently developed tool to provide information that can help consider suitable site characteristics in the MPA of PISISI. The combination of these two tools is still not widely used to design no-take zones. The study on the MPA of PISISI is expected to provide an example of how the information generated by these two tools becomes a reference or a model that will be applied to other MPAs.

Because of the importance of zoning in conservation areas and the importance of protecting no-take zone, it is expected that this zoning study will be able to answer the sustainable and responsible management of conservation areas. Therefore, this study aims to determine the location of the no-take zone based on conservation targets that have high biodiversity value, analyze the optimum size of the no-take zone, and determine the zoning design in the MPA of PISISI Simeulue District.

2. Materials and Methods

2.1. Research Location, Time, Tools, and Materials

This research was conducted in the MPA of PISISI from April 2019 to June 2020. The study area can be seen in Fig. 1.

The tools needed in the analysis process in this study are GPS and others related to marine sampling. The software used is ArcGis, QGIS with the addition of the Qmarxan plugin, and the MPA Size Optimization Tool. The materials used in this research are 1:50,000 maps, the MPA of PISISI maps, data on the distribution of coastal ecosystem habitats, high biodiversity or High Conservation Value (HCV), data on river estuaries, port areas, and shipping lanes.

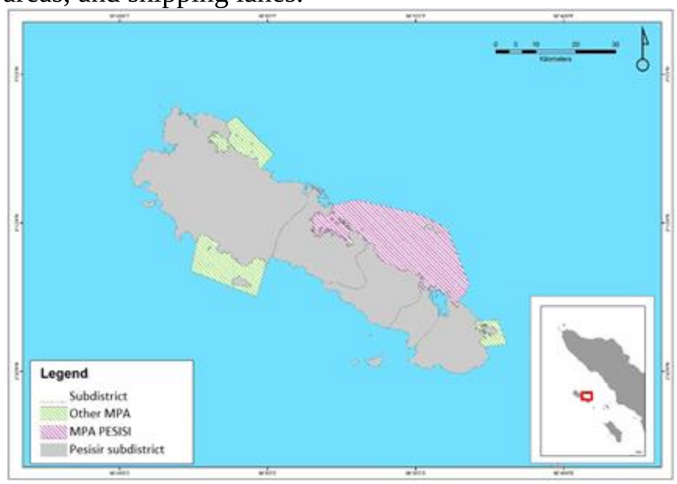

Fig. 1 The orientation map of the study area

2.2. Preparation and Data Collection

The data and information used as the material in this research were collected from various related agencies, which include spatial data and attributes as follows:

- The 1:50,000 map and administrative boundary maps in digital form are used as the basic material for making map layers.
- Data on the distribution of coastal ecosystem habitats in digital form.
- Descriptive data presented editorial or tabulated in the form of reports.
- High biodiversity data based on the results of studies that have been conducted.

To be more precise, the data used in the study were divided into two groups, the conservation feature group and the second is feature group (Table 1).

The research method used in this research was applying the secondary data analysis. Secondary data include those obtained from various sources and literature and the latest data that can be accessed. This research was conducted in several stages of activities: data preparation and collection, Marxan analysis, analysis of the optimum size of the no-take zone, and field activities.

2.3. The Marxan Model

The Marxan was used as a designer tool in determining the zone. The data used by Marxan is in the form of spatial data on conservation targets, costs, and planning units, which was used as Marxan input data according to the needs and requirements to determine the core zone or no-take zone [22, 23].

Table 1 Data sets used in the Marxan analysis

Data	**Year**	**Source**
Indonesia RBI Data	2017	Geospatial Information Agency
Coral Reef Distribution Data[1]	2007, 2009	Geospatial Information Agency
Mangrove Distribution Data[1]	2009, 2015	Geospatial Information Agency
Fish Abundance Data[1]	2018	*Reef Health Monitoring Survey* (Fauna Flora International)
Fish Diversity Data[1]	2018	*Reef Health Monitoring Survey* (Fauna Flora International)
Fish Biomass Data[1]	2018	*Reef Health Monitoring Survey* (Fauna Flora International)
Coral Cover Data[1]	2018	*Reef Health Monitoring Survey* (Fauna Flora International)
Coral Recruitment Data [1]	2018	*Reef Health Monitoring Survey* (Fauna Flora International)
Rubble Cover Data[2]	2018	*Reef Health Monitoring Survey* (Fauna Flora International)
Shipping Lane [2]	2018	RZWP-3-K Document Aceh
Harbor Area[2]	2018	RZWP-3-K Document Aceh
Estuarial Area[2]	2018	Digitation on Screen

Note: [1] Conservation feature and [2] Cost feature

The Marxan model selects an area of interest and creates a planning unit that is the smallest area for the analysis unit [19]. Furthermore, the conservation feature data is in the shapefile (shp) format put into the planning unit. The method used in this process is present or absent. This model does something if the units overlap with a conservation feature, then the hexagon with the present attribute; on the other hand, if the units do not overlap with the conservation features, it is called absent [12]. Likewise, for the input of cost feature data into the planning unit, the cost feature data must be in the shapefile format for spatial calculations in Marxan [22, 23].

2.3.1. Planning Unit or Area of Interest (AOI)

The planning unit is divided into several small areas covering the entire area of the research location. This planning unit was created to delineate the area that would be analyzed by Marxan. The shapes contained in this planning unit are triangular, rectangular, and hexagon shapes [24]. The planning unit is also the basis for Marxan calculations to determine the no-take zone after inputting the unit into conservation target and cost data. In this study, the form of the planning unit to be used is a square with a unit size of 200 m^2 (Fig. 2).

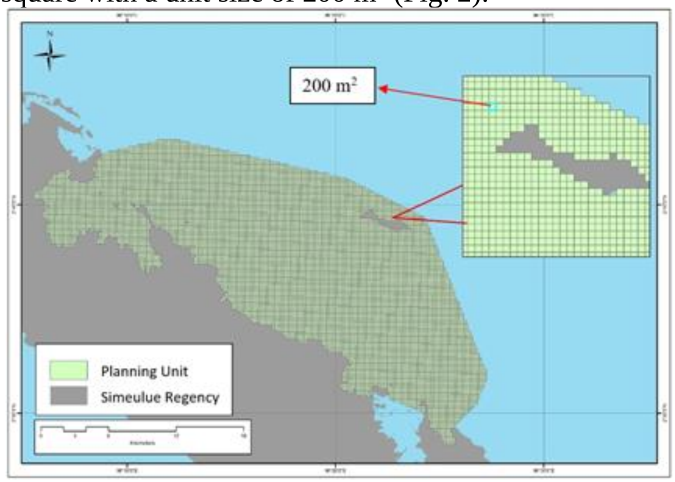

Fig. 2 Map of the MPA of PISISI planning unit with the rectangular grid

2.3.2. Conservation Targets

Conservation targets are important habitats contained in the MPA. Therefore, the Marxan input used was the ecological parameters that will be protected or those considered important. This parameter was in the form of important habitat distribution for coastal ecosystems (mangroves and coral reefs) because it can increase fish catches up to 80% "Maximum Sustainable Yield" and at least export larvae to other fishing locations [25]. Furthermore, High Conservation Value (HCV) is an important indicator and a priority target in determining no-take locations. These HCVs are areas that have the highest ecological value among other locations. There are seven priority targets needed, including high hard coral cover, high fish biomass, and a high fish abundance which are priority targets because they have many fish, high fish diversity, and high coral recruitment. The HCV value above is a very important consideration, so it must be conserved.

2.3.3. The Costs

The costs for Marxan input were in the form of social data relating to population, resource use patterns, area use, and the data that can increase management costs. According to [24], a cost value is based on the level of reasonableness and human influence in the planning unit. The cost in this study consists of three criteria: (1) areas that have high coral fracture cover because they will produce many algae so that coral larvae do not stick, (2) shipping lanes which are the use of environmental services that can harm the ecosystem and (3) the river estuary which is an area that often occurs sedimentation caused by discharge from the upstream. This sedimentation will cover the coral colonies so that the coral reefs die. This spatial approach is made by calculating the distance from the river mouth and port to the sea. The simple assumption is that the farther the reach from high coral reef cover, shipping lanes, ports, and river estuaries, the less it will affect the coastal ecosystem, and vice versa.

2.3.4. No-Take Zone Design Scenarios

No-take zone design scenarios are a solution or recommendation offered based on the results of Marxan calculations. In this study, the authors made a scenario as shown in Table 2. For conservation targets, coastal habitats (mangroves and coral reefs) receive a protection target of 20-30%, which is a conservation target recommended by the IUCN (International Union for Conservation of Nature) to contribute to global conservation targets. Based on the research results, protecting 20-30% of coastal habitats will increase fish catches by more than 80% and at least export 30% of larvae to fishing locations [25]. Furthermore, HCV (High Conservation Value) gets a protection target of 100% and a critical area of 30%. Furthermore, the cost variable (high coral fracture cover, shipping lanes, ports, river estuaries) received a weight of 100%. Determining the no-take zone later, Marxan did not choose an area that contained this cost variable.

2.4. Modeling MPA Size Optimization Tool

This tool is used to consider the size of the no-take zone according to the fish resources in the marine conservation area. This tool will consider some information such as the specific characteristics of fish species in the form of mean home range, density (abundance of fish species per square meter found in potential conservation areas and fish length (maximum length of certain fish species) can also be used as a value or number in predicting how effective the size of the no-take zone is at each level of protection [25]. This protection level is generally divided into two categories: partial protection (50% and 75%) and full protection (95 %).

The list of fish species inhabiting the no-take zone candidate in the MPA of PISISI will be used as data in the MPA size optimization tool to provide recommendations for the no-take zone size. This measure will later be used as a reference for the length (along the coastline at the reef edge) of the no-take zone. The size of the no-take zone is following the geomorphology of each potential area.

The stages of the study were done step by step based on the research interest. The stages, in brief, can be seen in the flow chart as shown in Fig. 3.

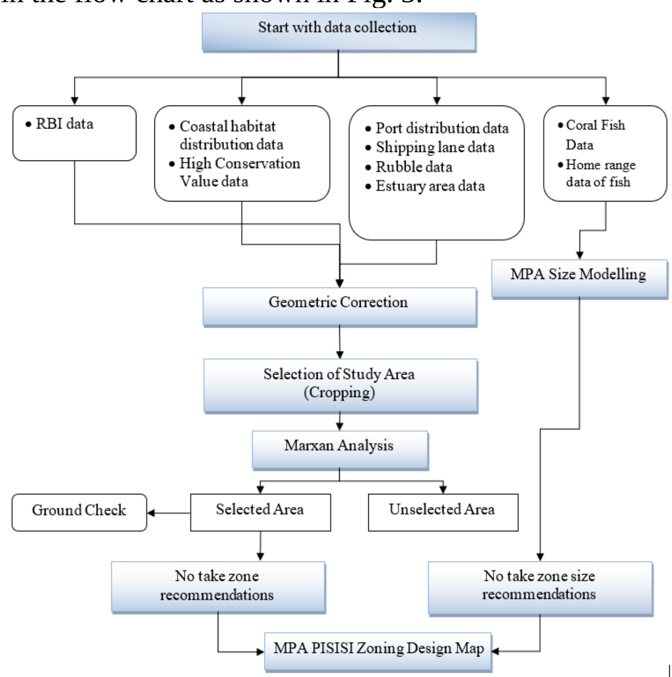

Fig. 3 Flow chart for research stages

3. Results and Discussion

3.1. Analysis of No Take Zone Locations in the MPA of PISISI

The study area used in the analysis to determine the no-take zone is 44,404.10 ha. This area includes coral reef habitats and seagrass habitats. In Fig. 4, the brown color shows the distribution of coral reefs, and the pink color shows the distribution of mangroves. Most of the mangrove habitat is in the mainland area; therefore, they do not include the study area. The coral reef habitat area in the MPA of PISISI is 6748.55 ha, and the mangrove area is 50.08 ha.

3.2. Coastal Habitats (Coral Reefs and Mangroves)

The study area used in the analysis to determine the no-take zone is 44,404.10 ha. This area includes coral reef habitats and seagrass habitats. In Fig. 4, the brown color shows the distribution of coral reefs, and the pink color shows the distribution of mangroves. Most of the mangrove habitat is in the mainland area; therefore, they do not include the study area. The coral reef habitat area in the MPA of PISISI is 6748.55 ha, and the mangrove area is 50.08 ha.

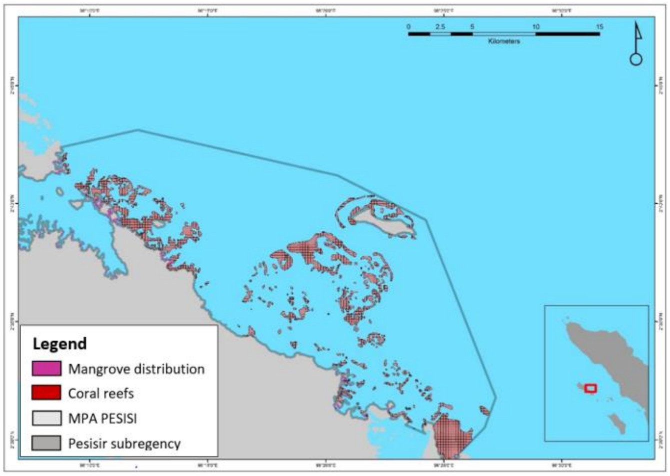

Fig. 4 Distribution of important coastal habitats based on the study of the Geospatial Information Agency (GIA) of Indonesia

3.3. Locations of High Biodiversity or High Conservation Value

In addition to important coastal habitat data, data from the results of an ecological survey conducted by FFI in 2018 at the MPA of PISISI, totaling 17 observation points in the Marxan analysis, are shown in Fig. 5. According to the no-take zone design scenario in this study, this ecological survey is intended to determine which locations have high biodiversity values (Table 2).

Table 2 No-take zone design scenario at the MPA of PISISI used for MARZAN model

Data	Factor	Parameter	Weight (%)
Conservation Targets	Habitat	Mangrove	30
		Seagrass	30
		Coral reefs	30
	High Biodiversity or High Conservation Value (HCV)	High hard coral cover	100
		High coral recruitment	100
		High fish biomass	100
		The high abundance of fish	100
		High fish diversity	100
		High fish capital	100
		High fish uniformity	100
Cost		High rubble cover	100
		Shipping lane	100
		Harbor/Port	100
		Estuary	100

The data that has been taken in this study are only locations that have high biodiversity value. They were found in Asa, Jawi, Putih, Bengkalak Island, Pinang Island, Simanaha Island, and Talam Island (Fig. 6) for high fish abundance.

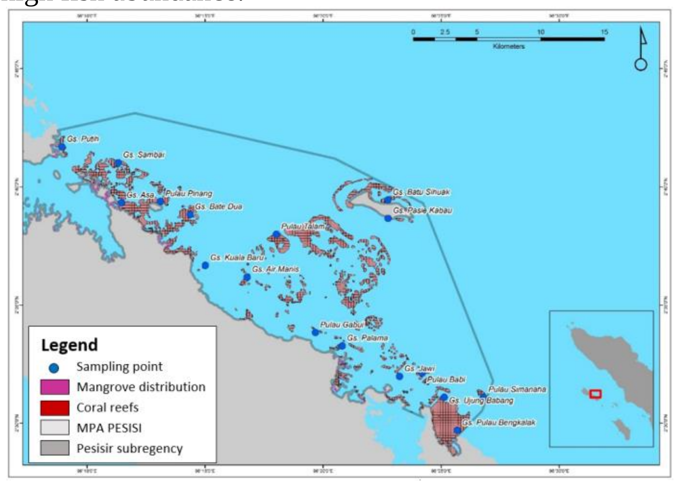

Fig. 5 Distribution of coastal habitat data based on FFI ecological survey location in 2018

The locations of high fish diversity were found in Asa, Jawi, Putih, and Batu Sihuak (Fig. 7). Furthermore, locations with high coral cover values were found in 12 locations, namely Bates Dua, Palama, Putih, Sambai, Ujung Babang, Kuala Baru, Bengkalak Island, Gabui Island, Pinang Island, Asa, Jawi, and Simanaha Island (Fig. 8). Then from the 17 observation locations, seven locations had high coral recruitment. The locations were Bates Dua, Asa, Jawi, Putih, Sambai, Kuala Baru, and Bengkalak Island (Fig. 9). Meanwhile, high fish biomass was only found in four locations, namely Air Manis, Jawi, Simanaha Island, and Talam Island (Fig. 10). Locations that have a high biodiversity value or High Conservation Value are briefly presented in Table 3.

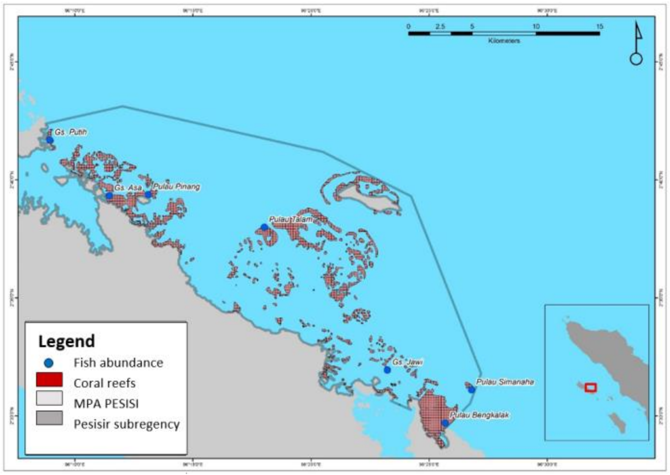

Fig. 6 Location of high fish abundance

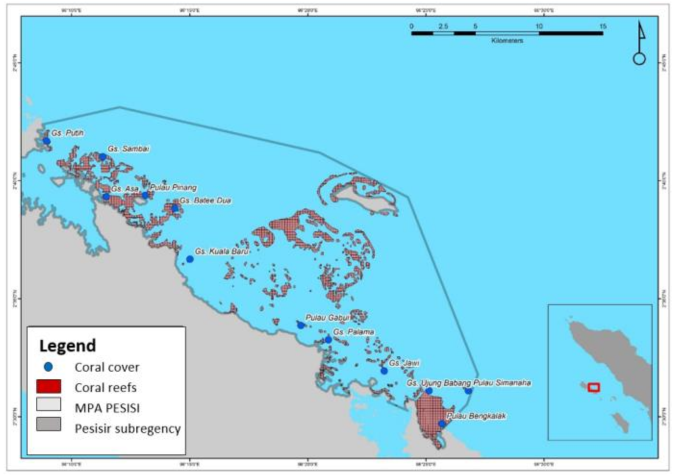

Fig. 9 High coral recruitment locations

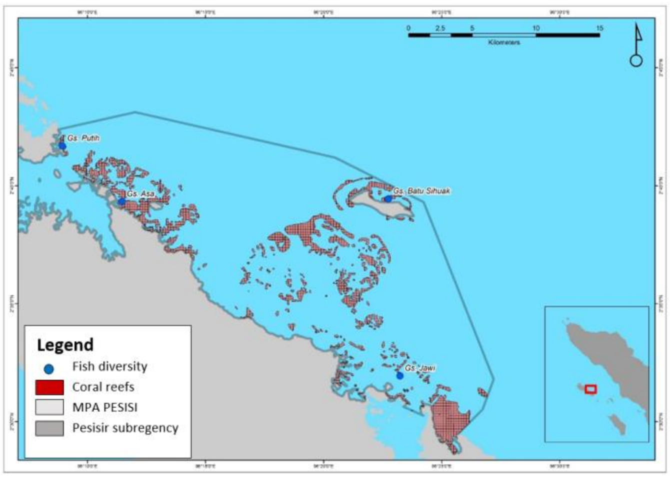

Fig. 7 Location of high fish diversity

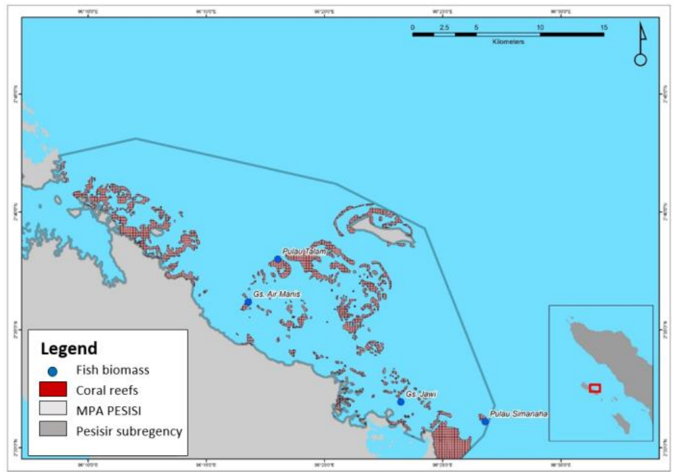

Fig. 10 Location of high fish biomass

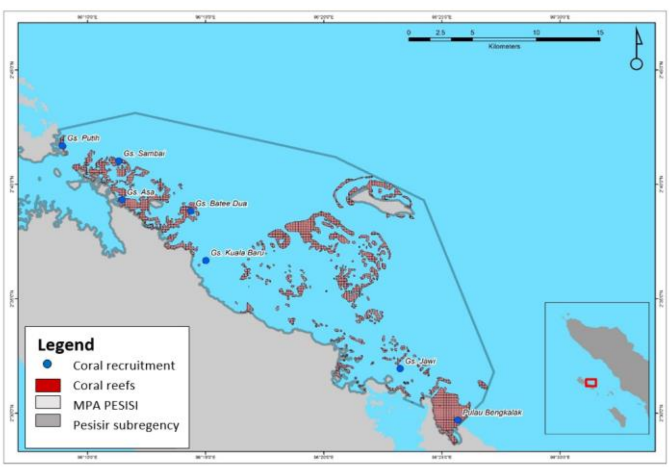

Fig. 8 Location of high coral cover

Table 3 Locations with biodiversity value or high conservation value

Location Name	**Category**				
	Fish Abundance	**Fish Diversity**	**Coral Cover**	**Coral Recruitment**	**Fish Biomass**
Air Manis					√
Pasie kabau					
Batee Dua			√	√	
Asa	√	√	√	√	
Jawi	√	√	√	√	√
Palama			√		

Putih	√	√	√	√	
Sambai			√	√	
Pulau Babi			√		
Pulau Bengkalak	√		√	√	
Pulau Gabui			√		
Pulau Pinang	√		√		
Pulau Simanaha	√		√		√
Pulau Talam	√				√
Batu Sihuak		√			
Ujung Babang			√		
Kuala Baru			√	√	

The cost value in the MPA of PISISI is presented in Figure 11, which concerns aspects of shipping lanes, estuaries, and rubble cover. The shipping channel is obtained from the Aceh RZWP3K (Coastal Zone and Small Islands Zoning Plan) document in 2018. This shipping lane is a channel used for the benefit of passenger and cargo ports which is also one of the human activities that have an impact on the survival of larvae and juvenile marine biota, which can be disturbed by ocean waves generated by ships and carried by ship water ballasts [26-28]. Furthermore, river estuaries, as one of the producers of sedimentation, can cause damage to an ecosystem. This sedimentation resulted in the death of stony corals during the coral recruitment process [1]. Sedimentation can also make coral polyps closed so that zooxanthellae in symbiosis with corals do not get chlorophyll intake which will make the coral die. The sedimentation area is obtained from the results of the on-screen digitization that has been done. Additionally, the highest coral cover was found in Sambai, Batee Dua, Air Manis, Pinang Island, Babi Island, and Gabui Island. Coral fracture is one of the effects generated by waves and currents and cannot be used as a substrate for new coral recruitment.

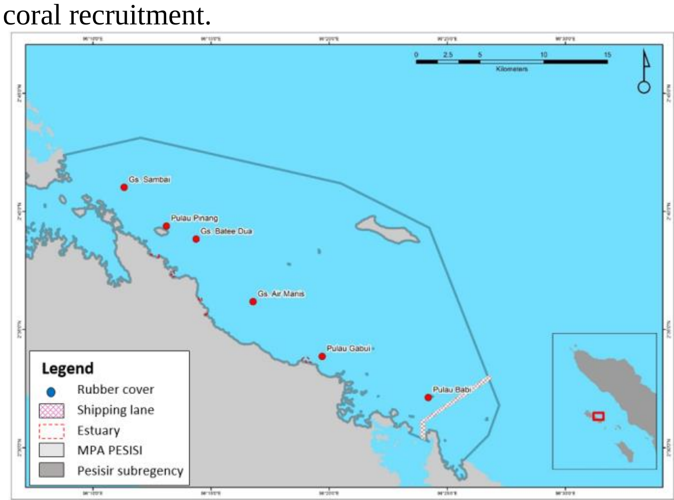

Fig. 11 The cost location in MPA of PISIS

3.4. The No Take Zone Locations

Based on the Marxan analysis results following the scenario that has been made (Table 2), the blue color in Figure 12 is the best solution, which indicates that the selected area is the best location. The area designated based on the results of the Marxan was 733.97 ha, all of which were divided into eight parts.

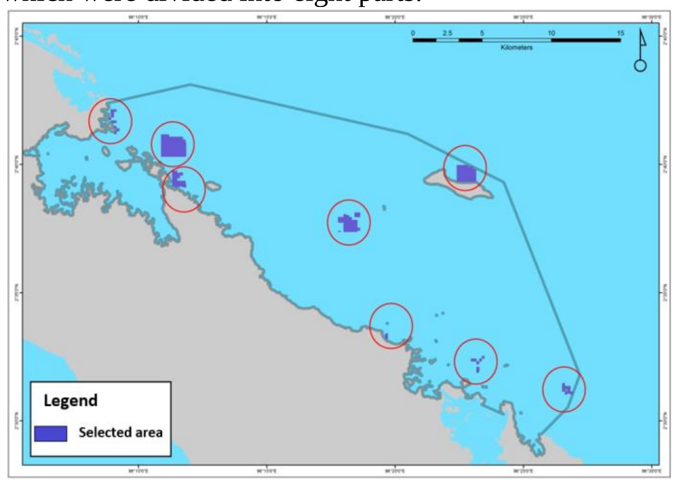

Fig. 12 No-take zone areas selected by Marxan

In general, Marxan has met the targets according to the initial planning in the scenario (Table 2), both in terms of habitat area and priority HCV locations. The area selected by Marxan is evenly distributed from the western region to the eastern region of the study area. Then in the process of this analysis, Marxan has performed 100 times iteration where these results get the same results (steady state).

3.5. Analysis of the No-Take Zone Optimum Size in the MPA of PISISI

In total, in the PISISI area, 343 fish species were found obtained from the FFI survey results in 2018. However, only 55 species were included in this analysis; these species have a high economic value from the family Caesionidae, Carangidae, Haemulidae, Serranidae, Lutjanidae, and Serranidae. The proposed optimum size for a no-take zone in the MPA of PISISI is 3 km obtained from the species entered in the MPA Size Tool modeling. This calculation is based on the results of the home range and the maximum length of the fish.

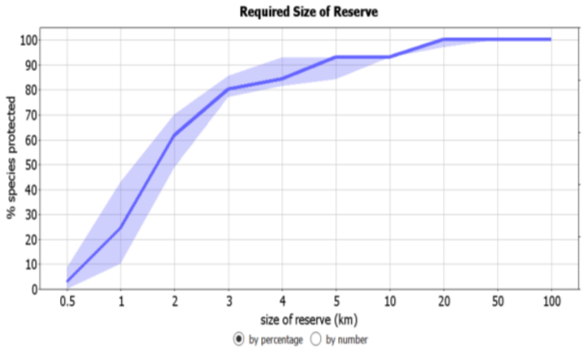

Fig. 13 No-take zone length measurement result from MPA modeling

The result of modeling the no-take zone size is 3 km which can protect 80% of fish species having economic value identified in the MPA of PISISI (Fig. 13). The length of the no-take zone is parallel to the coastline (Fig. 14). The area of the no-take zone from this modeling is 5,474 ha from the total area of the MPA of PISISI, which is 44,404.10 ha, meaning that if a percentage on the size of the proposed no-take zone is 10.60%. With an area of 5474 ha, it has a protected coral reef habitat of 2,009.95 ha from 6,748.55 ha of coral reef habitat in the MPA of PISISI with a percentage of 29.78%. It also protects mangrove habitat of 16.8 ha from 50.08 ha mangroves indicated in the MPA of PISISI with a percentage of 33.55%. In terms of habitat proportion, the no-take zone that has been selected has filled 20-30% of the total habitat in the MPA of PISISI.

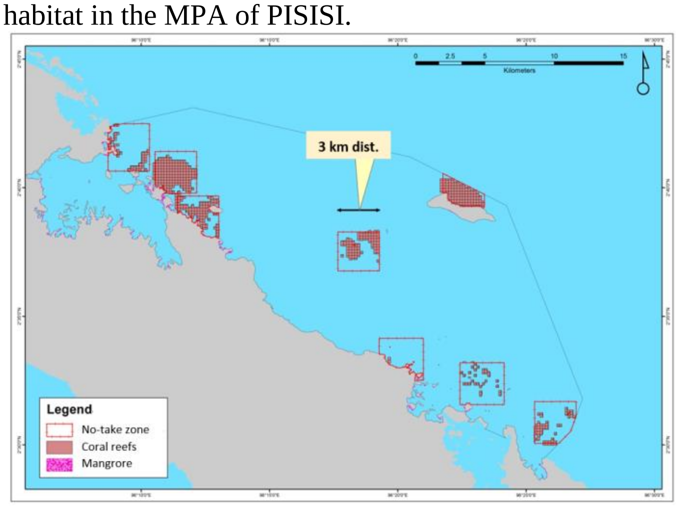

Fig. 14 Map of no-take zone size in the MPA of PISISI of Simeulue District

3.6. Proposed Zoning Design in the MPA of PISISI

Based on the results of the Marxan analysis and the analysis of the optimum size of the no-take zone in the MPA of PISISI, the authors propose two categories (Fig. 15). Category 1 consists of four zones (I, II, III, and IV), and category 2 also in four zones (A, B, C, and D). Category 1 is the proposal for the core zone, while category 2 is for the use zone. Category 1 protects the coral reef habitat of 1593 ha with a percentage of 23.62% and protects the mangrove habitat of 11.33 ha with a percentage of 22.62%. Meanwhile, the category 2 proposal protects the coral reef habitat of 416.18 ha with a percentage of 6.17%, then protecting 4.47 ha of mangrove habitat with a percentage of 10.92%. This proposal has achieved all of the targets specified in the scenario, namely protecting high-diversity coastal habitats. For more details, the proportion of the habitat area that has been protected in the zone can be seen in Table 4.

Table 4 The proportion of habitat area in no-take zones

	Proposed Core Zone (ha)				
Proportion	**I**	**II**		**III**	**IV**
Coral Reefs	596.28	320.24		304.52	372.73
Mangrove	5.86	5.47		-	-
		Proposed Utilization Zone (ha)			
Proportion		**A**	**B**	**C**	**D**
Coral Reefs		133.08	-	120.28	162.82
Mangrove		4.05	-	1.42	-

The results of the model above, the authors try to re-layout according to government regulations regarding donation (Fig. 16) and display the area of each zone (Table 5). The core zone and the use, zone are the results of the Marxan analysis and analysis of the optimum size of the no-take zone, while the other zones are taken from locations with high coral cover where the allocation is for rehabilitation, and the sustainable fisheries zone is a zone outside the core zone, the use zone, and other zones.

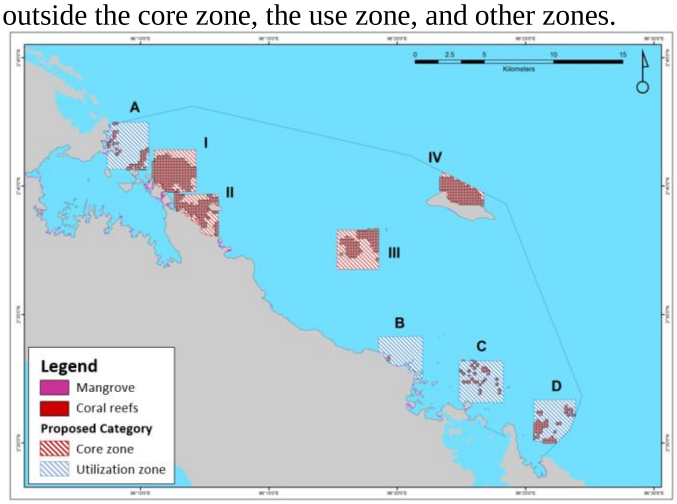

Fig. 15 Zoning proposed in the MPA of PISISI of Simeulue District

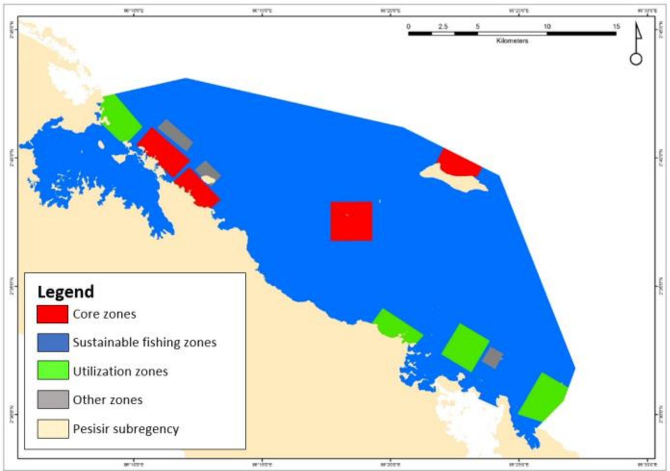

Fig. 16 The final proposal of the MPA of PISISI zoning design for Simeulue District

Table 5 Zoning area in the MPA of PISISI of Simeulue Regency

Zonation	Area (ha)	%
Core Zone	2.283,89	5,14
Utilization Zone	2.421,41	5,45
Other Zone	508,65	1,15
sustainable fishing zone	39.190,15	88,26
Total	44.404,10	100,00

The zoning design proposals that have been made have overall achieved the conservation targets through the scenarios in Table 2. This scenario is in line with the MPA's objectives as a method to protect biodiversity and fisheries resources for local communities in particular. Protected ecosystem conditions can still provide fisheries benefits. The combination of conservation area design tools has helped managers determine locations to be managed or used as no-take zones. This zoning design is expected to be one of the models in determining no-take zones in the reserved MPA, but there is no zoning management plan in Aceh in particular. The two tools used in this study are only supporting tools to determine a better MPA management plan.

6. Conclusions

The location of the no-take zone in the MPA of PISISI Simeulue District is divided into eight parts. The model results optimize that the no-take zone size is 3 km with 80% protection of the 55 high-economic fish species contained in the MPA of PISISI. Meanwhile, the proposed zoning design in the MPA of PISISI consists of a core zone with an area of 5.14%, a sustainable fishery zone with an area of 88.26%, a utilization zone of 5.45%, and another zone with an area of 1.15%.

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