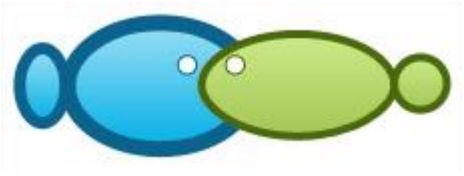

Management and protection of the Rhinidae family in the Java Sea, Indonesia

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Abstract. Excessive exploitation of stingrays causes the threat of extinction of stingray species in Indonesia. Overfishing stingrays has endangered them. Overfishing occurs due to the high demand for stingray meat, skin, and fins. The purpose of this study is to map the catchment area of stingrays so that strategies can be developed in achieving their sustainability in the waters. The utilization rate of stingrays in the Java Sea reached 62%. Stingrays in WPP712 (Fisheries Management Area) were mostly captured around Maselembu Island, north of Bawean Island, south of Kalimantan Island, and around small marine islands. Stingrays are found on a specific sandy mud substrate near reefs, at a depth range of 0-40 m. The average number of *Rhynchobatus* spp. stingrays caught in the rainy season (Nov- Apr) was 5742, while the captured *Glaucotegus* sp. number reached 1316 in the dry season (May-Sep). The strategic priorities needed are complete control of the trade in stingrays, especially protected rays inside and outside the country, and the determination of stingray conservation areas, for stingrays included in the Red List and CITES I and II. Therefore, it is required to conduct further in-depth studies regarding the stingray productivity in Indonesia related to the number of species. There is a need to conduct socialization regarding the size and catching quota of protected rays by involving related stakeholders.
Key Words: AHP, conservation, Java Sea, spatial model, SWOT.

Introduction. Indonesia is the third country in the world in terms of stingray exploitation after China and Thailand (Yuwandana et al 2020), according to data from the International Union for Conservation of Nature (IUCN) in 2015. Hunting and over-fishing of stingrays have caused the endangerment of stingray species due to high market demand for stingray skin, fin, and meat (Wijayanti et al 2018).

Stingrays are usually caught as by-catch and main catch in drag nets, gill nets, or bottom long lines. Stingray is a fishery commodity that makes a significant contribution to improving the economy of fishermen on the north coast of Java Island, especially in Muara Angke (Jakarta), Cirebon (West Java), Tegal (Central Java), Juwana (Central Java), and Brondong (East Java) (Satiati et al 2020). The high utilization levels have caused rays to become vulnerable to extinction. This is related to the biological characteristics of sharks and rays, which have long life spans, slow growth and sexual maturation, and low fecundity.

The rise of stingray catching is an effect of community open access resources. Furthermore, there is often an assumption that they have shared ownership (common resources), resulting in excessive exploration, overfishing, and even extinction (Hakim et al 2014). The decrease in the population of *Rhynchobatus* spp. is due to the high catching effort to meet market demand for the stingray fin and meat. The development of the export market to meet the demand for ray fins has resulted in a significant increase in the rate of catching rays. Moreover, it is a worry regarding the threat of extinction of these species in the future (Sadili et al 2015).

This study aims to determine alternative resource management strategies for *Rhynchobatus* spp. in the Java Sea to prevent the extinction of the ray species in nature. Strategy policy determination was carried out using the AWOT approach. AWOT is a SWOT analysis integrated with AHP (Analytical Hierarchy Process) analysis and determines the IUCN conservation status of the ray family Ranidae in the Java Sea.

Material and Method

Location and time of research. The study was conducted along the north coast of Java (Figure 1), the center of the most significant fishing activities for the Ranidae family rays on the north coast of Java in Cirebon, Tegal, and Lamongan. The data collection was conducted in February 2023, and the secondary data was stingray catching information from 2019-2022. The methods used were surveys and interviews as research instruments.

The Fisheries Management Area 712 is in the north of Java Island, including 58 TPI in regencies/cities in eight provinces, Lampung, Banten, DKI Jakarta, West Java, Central Java, East Java, Central Kalimantan, and South Kalimantan Provinces. WPPNRI 712 includes the Java Sea, which is geographically connected to the South China Sea through the Karimata Strait (Kurniawati et al 2015).

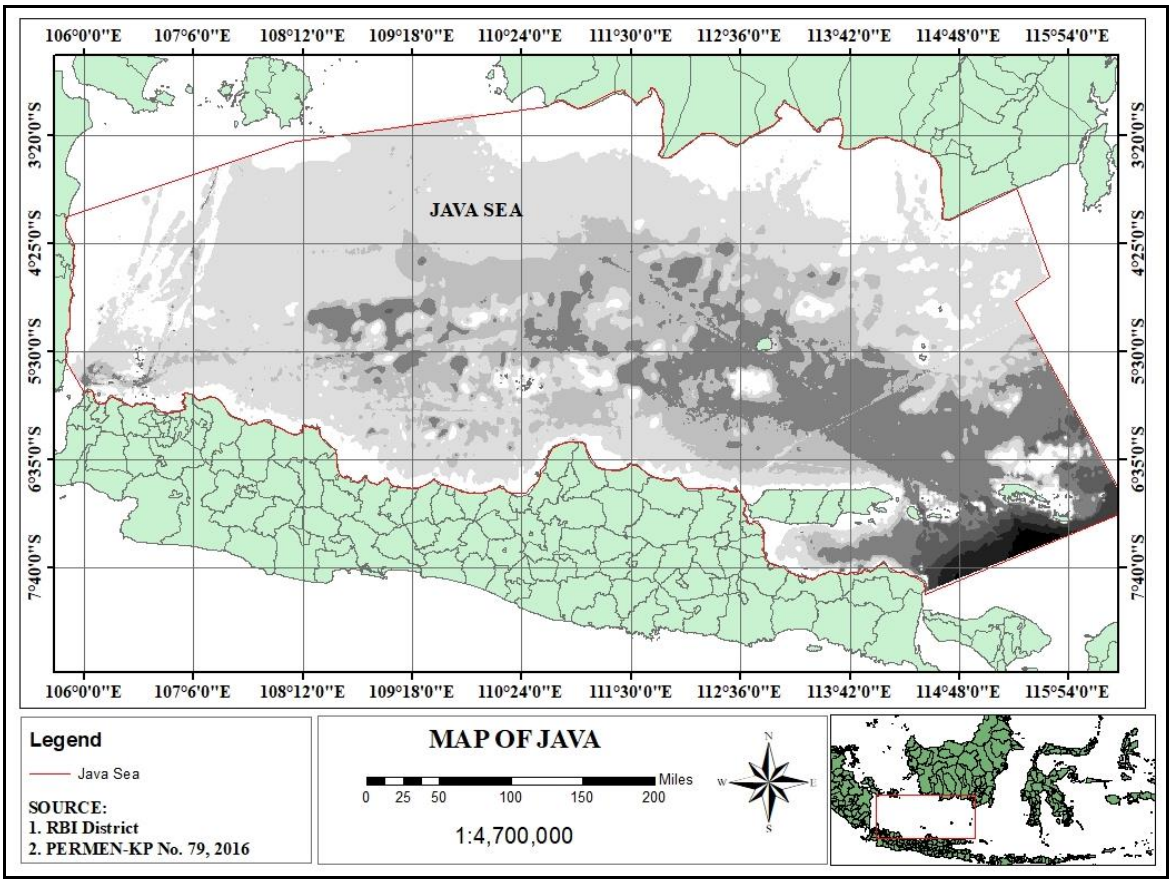

Figure 1. Research site.

Data collection. The primary data on fish production was collected from interviews with competent key persons. The respondents were selected by purposive sampling based on roles and expertise. The respondents in this study consisted of fishermen (6), port masters (3), fish auction venue employees (3), Maritime Affairs and Fisheries Service employees (3), traders (3), and academics (1). Primary data consisted of internal factors and external factors in the management of fish resources of the Rhinidae family in the Java Sea. Furthermore, the number of rays caught and the location of the catch was determined collecting information from fishermen. Coordinates of stingray fishing areas were obtained from fishermen who catch stingrays in the waters of the Java Sea. The secondary data collected were data on the production of stingrays, species of stingrays caught, and data on fishing gear and trips. Secondary data collection was carried out from several agencies, including PPN Kajawanan (Cirebon), PPP Tegalsari (Tegal), PPN Brondong (Lamongan), and Rekam Nusantara.

Morphology of captured stingrays. Biological aspects observed included the total length of fish and species identification. Data collection was conducted every day. The total length of the stingrays was measured using a tape measure from the tip of the snout to the back of the caudal fin (Oktaviani et al 2020). The length data were used to analyze size distribution and identify the species of rays caught. Identification of stingrays refers to Jabado (2019).

Bathymetry. Processing the bathymetry map aimed to sharpen digital data into a better display. The results of image processing in digital maps were not easy to interpret directly, so GIS technology was required to describe them in thematic maps. Image data processing used was bathymetric data obtained from the GEBCO.id site and then processed using the Ermapper application.

Spatial distribution. Spatial data processing combining stingray catches and catch coordinates were processed with the ER mapper application. The stages of the data processing procedure carried out are as follows.

Plotting the coordinate points aimed to find out the location of the arrest and change the format of the coordinate points obtained from GPS (Degrees, Minutes, Seconds) to decimal degrees because in subsequent processing in the ER-Mapper 7.0 software, coordinate points must be used in decimal degrees format.

Gridding transforms field coordinate point data and supporting variables into spatial layers (Hartoko & Helmi 2004). Gridding aimed to determine the distribution of coordinate points and their catch values. The data used in this gridding process were coordinate points (decimal degrees) with the catches of the stingrays. The gridding process and the layout creation process used the ER-Mapper 7.0 software, and the results were overlaid with cropped bathymetric data.

Cropping aimed to adjust the size of the image and limit the observation area to the object to be studied. Bathymetry data were cut according to the research location and the waters of the Java Sea.

Counting contouring is a process for displaying the contours of a surface that are differentiated in the form of lines. The purpose of this counting is to determine the depth of the Java Sea, especially at the location where the stingrays are caught.

The overlay was done by comparing the existing and processed data. The purpose of overlaying is to see if there is a change or difference between one data point. The data overlaid in this study were the results of gridding and cropped bathymetry data.

Making a map layout due to data processing in the ER Mapper software aims to clarify and provide a map view and the data. The results obtained were displayed in the form of a distribution map.

Analysis of production results by catch. The data analyzed were from VAT data from Kejawanan (Cirebon), PPP Tegalsari (Tegal), and PPN Brondong (Lamongan) for a period of 5 years, regarding stingray production and fishing efforts.

Catch per unit effort (CPUE) = Catch (individuals)/Effort (trips)

Estimation of the utilization level was carried out to determine the level of utilization of stingray resources in the Java Sea. Estimation was done by presenting the number of catches in a particular year with the maximum sustainable potential value (MSY). The equation for the utilization rate is the following (Latukonsina 2010):

$$TPc = (Ci/MSY) \times 100$$

Where: TPc - utilization rate in year i (%); Ci - fish catch in year i (tons/year i); MSY - maximum sustainable yield (tons/year).

Estimation of the level of effort was carried out to determine the level of effort needed to catch fish resources in Pemalang waters. Estimation was done by presenting the

standard effort in a certain year with the optimal effort value (Fopt). The equation of the effort level is the following (Latukonsina 2010):

TP = (fs/Fopt) x 100

Where: TP - level of effort in year i (%); fs - catching effort (standard effort) in year i (trips/year i); fopt - optimum catching effort (tons/year i.)

Analysis of the protection status of captured rays. Knowing the protection status of the stingrays captured is essential because it can control the management of fishery resources. The species of stingrays caught were identified, so that their protection status could be determined. The protection status comes from Government Regulations, CITES, and the IUCN Red List. Government regulations can be in the form of regulations from the Minister of Marine Affairs and Fisheries (ministerial regulation), decrees from the Minister of Maritime Affairs and Fisheries, and circular letters from the Directorate of Conservation and Marine Biodiversity (KKHL). CITES also issued protection status through regular meetings and grouping of species in: Appendix I, Appendix II, and Appendix III. The IUCN also issued other protection statuses through the red list. The red list can apply according to the start date of the status assignment.

The conservation status review follows the IUCN (International Union for Conservation of Nature and Natural Resources) list, and trade status follows the CITES (The Convention on International Trade in Endangered Species of Wild Fauna and Flora) list. Stingray data were analyzed in a comparative descriptive way by comparing the species of stingrays traded at the north coast of Central Java with those of stingrays included in the IUCN conservation status categories and CITES trade status. The collected data were then analyzed.

Analysis of the stingray fishery management using the AWOT approach. The data analysis method combined a hierarchical structure with SWOT strategic planning to determine the best priorities for the available alternative strategies. The analytic hierarchy process (AHP) is a hierarchical decision-making model that arranges multi-criteria problems (Imelda et al 2019). The AHP principle is the simplification of a complex, unstructured, strategic, and dynamic problem into its parts and arranging them in a hierarchy (Henríquez-Antipa & Cárcamo 2019). In this study, the two stages of the AWOT method were carried out as follows: (1) identifying the strengths, weaknesses, opportunities, and threats of managing *Rhynchobatus* spp. resources in the Java Sea using the SWOT method; and (2), performing the AHP. The steps of the SWOT analysis are presented in Table 1.

Table 1

SWOT analysis steps

Stages	*Steps taken*
1	Understanding the situation from key information
2	Understanding the problems that occur in the field, both general and specific
3	Determining alternative strategies based on existing information
4	Evaluating alternative strategies and determining strategic priorities

Results. The catch in Java Sea waters is dominated by *Lutjanus* spp., *Saurida* spp., *Upeneus* spp., and *Priancathus* spp. The fishing gear commonly used by fishermen to catch demersal fish in Java Sea waters are cantrang, gill nets, and bottom longlines (Dsikowitzky et al 2019). Fishing boats operating in WPPNRI 712 comprise 123239 units with 8 groups of fishing gear (Figures 2 and 3).

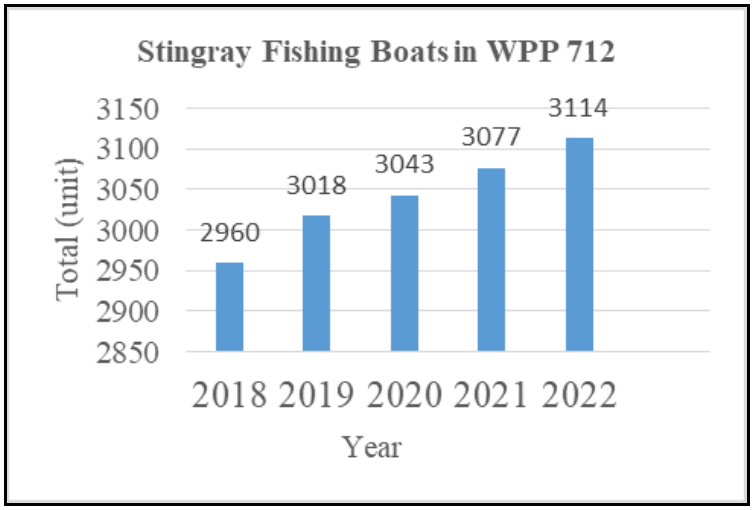

Figure 2. Total fleet >30 GT.

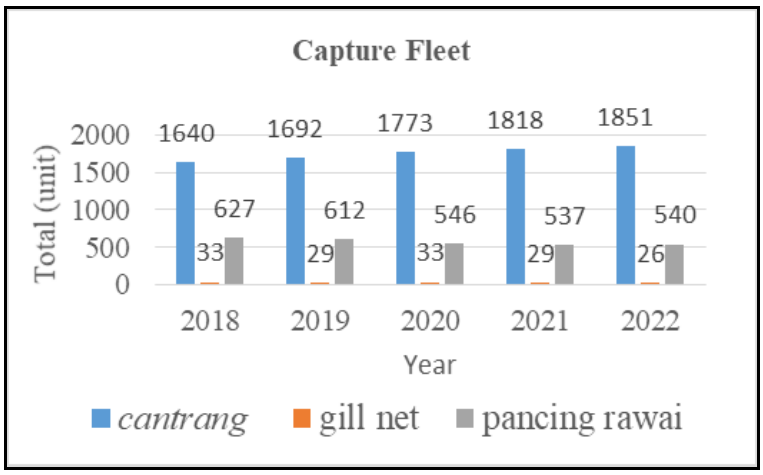

Figure 3. Types of fishing gears operated to catch stingrays (*Rhynchobatus* spp.) in WPP 712.

Morphology. Stingrays are estimated to have more than 300 species and are cosmopolitan in the sea. The geographic distribution of stingrays is extensive. Stingrays are found in tropical, subtropical (temperate), and cold Antarctic waters. As for the classification of stingrays from the genus *Rhynchobatus*, according to Simeon (2019), they are from kingdom Animalia, phylum Chordata, class Chondrichthyes, order Rhinopristiformes, family Rhinidae, with the following species captured in the Java Sea: (1) *Rhyncobatus australia*, (2) *Rhyncobatus springer*, (3) *Rhynchobatus laevis*, (4) *Rhina ancylostoma*.

The general characteristics of Rhynchobatus spp. are as follows: Spiracles have 2 distinct skin membranes, small eyes, short lower caudal lobe, small enlarged spines along the dorsal midline, large nostrils, and 2.2-2.4 times the distance between narines (White et al., 2006). Captured Rhynchobatus spp. had a total length ranging from 40-150 cm and were most commonly caught at 70-95 cm. Juvenile rays with a total length range of 40-60 cm were found around the coastal waters of mangrove forests and coral islands. Adults were found farther offshore at depths of around 100m.

Bathymetry. The Java Sea has an average depth of 40 m with a maximum width of 300 km and a length of 1000 km. The northwestern part of Java and the Karimata Strait have a depth of 30 m, the middle part has 60 m depth, and the eastern part (Madura island) has 90 m depth. The waters are relatively shallow and gently sloping with tropical aquatic

ecosystems, making the Java Sea a utilization area used for various fish. In addition, the Java Sea is influenced by substantial winds mixing water masses, making a homogeneous layer. The sea surface temperatures in Indonesia tend to be warm and do not change much throughout the year (Figure 4).

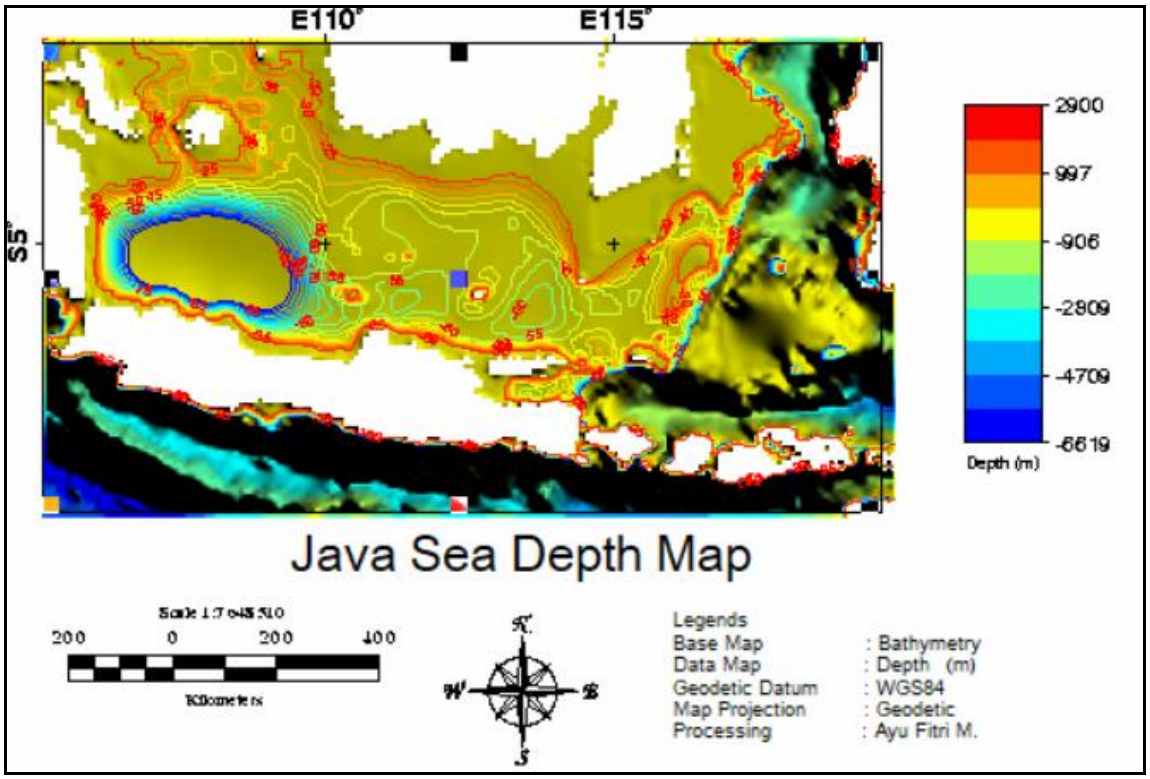

Figure 4. Java Sea bathymetry map.

The depth in WPP 712 was 70 m on average, with a relatively shallow and muddy sand substrate. The habitat of stingrays is the bottom of shallow coastal waters with a substrate of sand and mud near coral reef flats, lagoons, bays, and river mouths. The stingrays *Rhynchobatus* spp. are known to live at depths of 0-60 m (Kyne et al 2019). According to Kusrini & Aba (2019), these species generally inhabit the bottom of the waters, but many juveniles are found around the coastal waters of mangrove forests and coral islands. Meanwhile, adult rays were found in deeper offshore areas. Based on the results of interviews with cantrang fishermen, the operation of the cantrang fishing gear at PPP Tegalsari was conducted at depths of 20-30 m. Wedgefishes are rays that live in coastal and shallow waters up to a maximum depth of 70 m.

Spatial distribution of Rhynchobatus. The distribution area of stingrays *Rhynchobatus* spp. is coastal waters and sometimes tidal areas. Not infrequently, these animals are found at the bottom of muddy waters, hard soil, sandy mud, and rocky bottom. Stingrays *Rhynchobatus* spp. are commonly found in tropical marine waters. In the tropical waters of southeast Asia (Thailand, Indonesia, Papua New Guinea) and South America (Amazon River), many species of stingrays migrate from marine waters to fresh waters, spreading over a wide range (Kinakesti & Wahyudewantoro 2017). In Indonesian waters, stingrays are caught almost all year round. One example of a stingray that lives in waters with mud substrates is *Rhynchobatus* spp. Occasionally, this species lives on coral reefs and estuarine areas. The distribution pattern of stingray fishing can be seen in Figures 5 and 6.

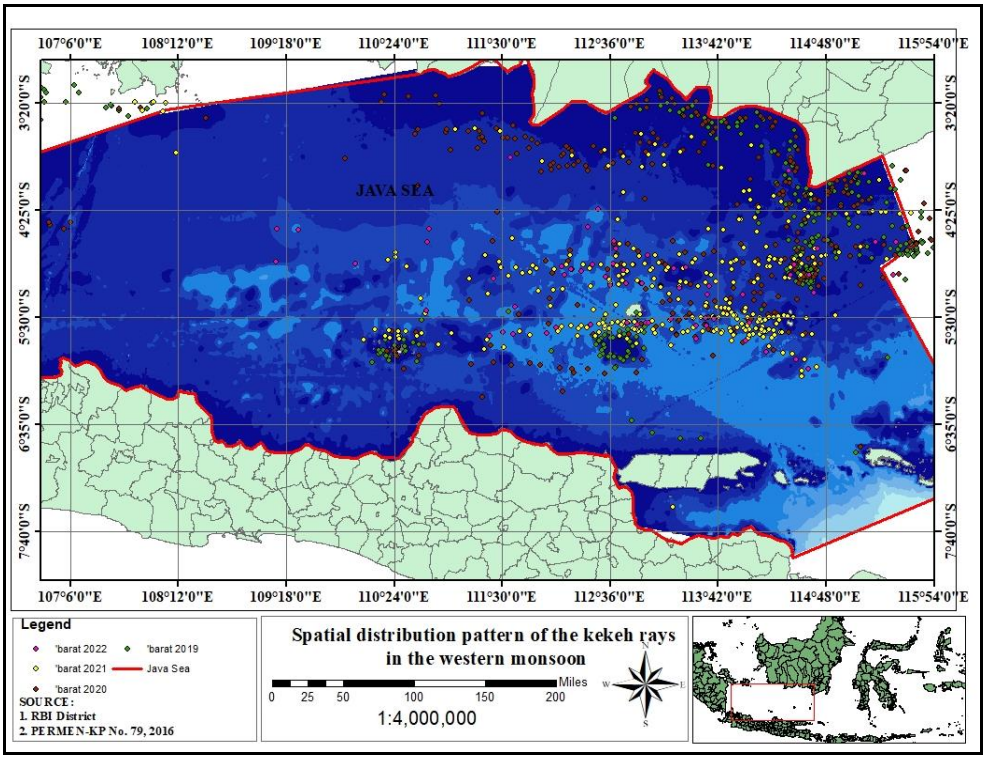

Figure 5. Spatial distribution of stingrays *Rhynchobatus* spp. captured in the west season.

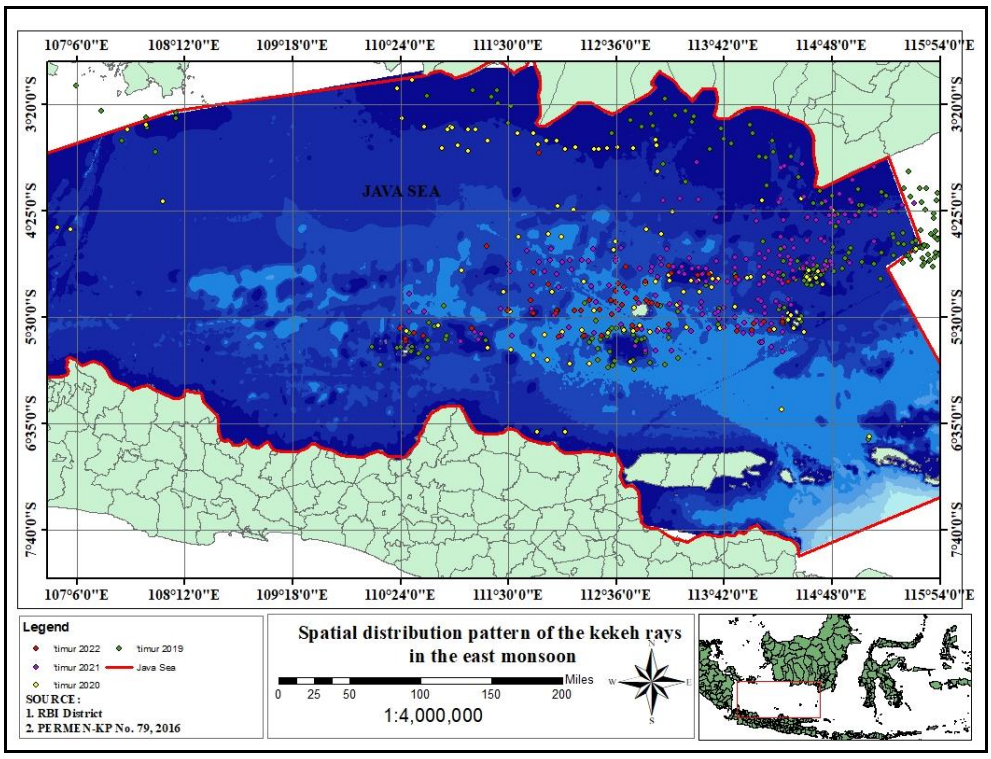

Figure 6. Spatial distribution of stingrays *Rhynchobatus* spp. captured in the east season.

The waters of the Java Sea have two patterns of the spatial distribution of stingrays *Rhynchobatus* spp., which spread away from the island during the east season and around the island during the west season. Based on the assumption that stingrays *Rhynchobatus* spp. are a demersal fish species, a bathymetry or depth analysis was conducted regarding the distribution of the captured rays (*R. springeri, R. laevis, Rhina ancylostoma* and *R.*

australiae) according to the ecology of their habitat (Figure 7). The stingrays *Rhynchobatus* spp. caught in the Java Sea waters are dominated by *R. australiae* species. *Rhynchobatus* spp. caught in the western season reached 4182 rays, and in the eastern season, reached 3019 rays. The highest catch of stingrays was of *R. australiae* in the rainy season, with 63 rays per month, while in the dry season it was 48.

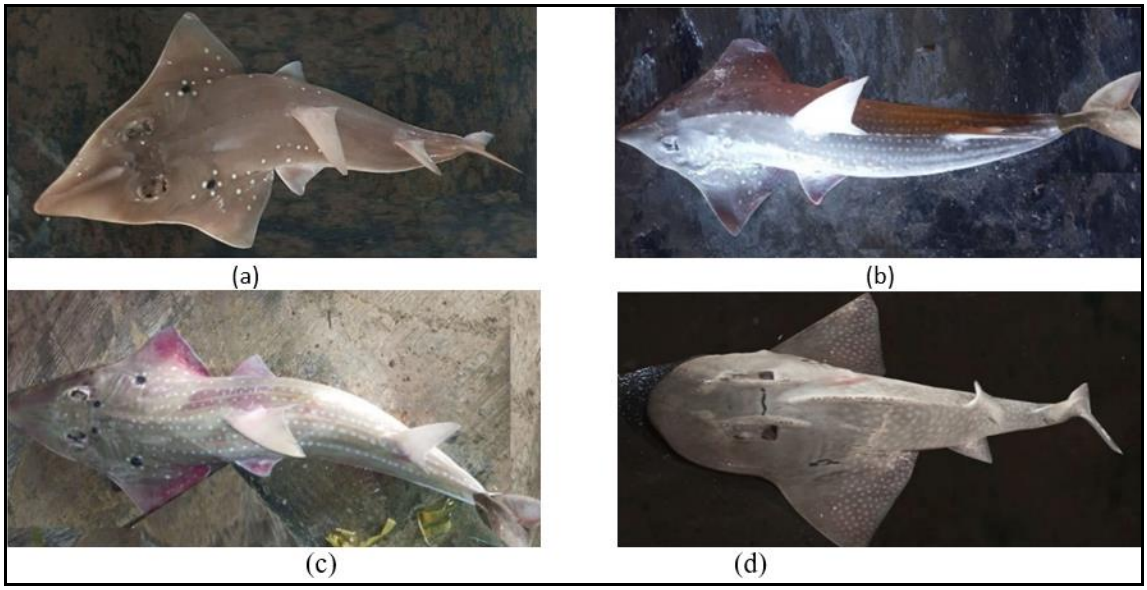

Figure 7. a - eyebrow wedgefish (*Rhynchobatus australiae*); b - Liong bun ray (*Rhynchobatus laevis*); c - *Rhynchobatus springeri*; d - smooth butterfly ray (*Rhina ancylostoma*).

Catch production. *Rhynchobatus* spp. is a by-catch from the cantrang fishing gear operating in WPP 712. A larger stingray will have a larger fin, affecting its price. The stingray production in WPP 712 is presented in Figure 8.

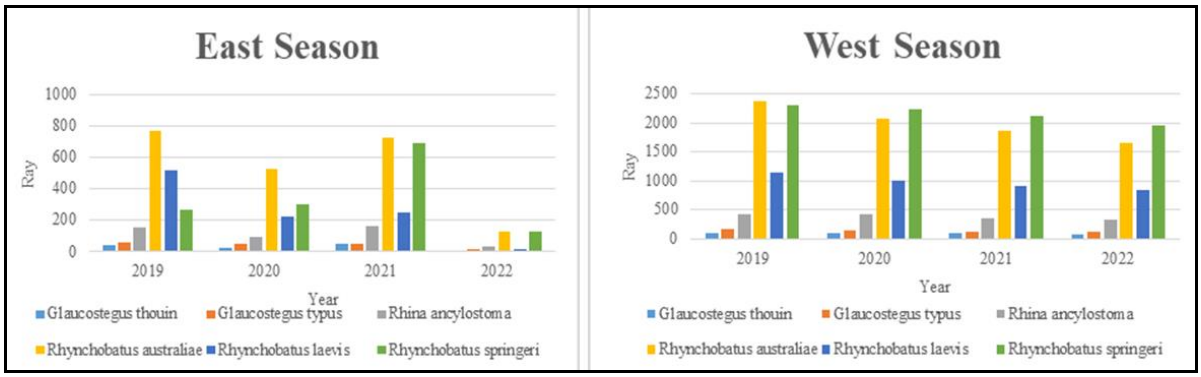

Figure 8. Production development of stingrays (*Rhynchobatus* spp.) captured.

The fishing season for stingrays in WPP712 was the western season, with an average of captured stingrays and shovelnose rays for 4 years of 5742. Meanwhile, the average number of stingrays and shovelnose rays caught in the east season reached 1316. In the west season, *Rhynchobatus* spp. are generally caught near the islands. The research showed that most *Rhynchobatus* spp. were found around the Masalembu and Kangean islands. This was presumably because, around the islands, the stingrays take shelter from extreme weather and high waves (Yuwandana et al 2019). The peak season fishing grounds are in the waters of Kangean Island, while the medium and lean seasons are in Masalembu Island and the northern waters of Bawean Island. Stingray production has decreased in quantity and quality, where the number of stingrays caught from 2019 to 2022 has

decreased, as well as the size of the stingrays. Information on trends in Stingrays(Rhynchobatus spp) caught can be used as a reference to determine fisheries management policies. (Hue et al 2018).

Fish resource utilization. There were 27337 individuals of *Rhynchobatus* spp. caught between 2019 and 2022. The stingray species frequently caught and landed on the north coast of Java each have their own protection status. there are three main threats identified exploitation, habitat loss and degradation all of which lead to mass extinction of fish species in waters. The utilization status of stingrays is presented in Table 2.

Table 2

Resource utilization of *Rhynchobatus* spp. in the Java Sea

Year	*Effort (X)*	*Catch (kg)*	*CPUE (Y)*	*TPC*	*Effort level*
2018	31918	2833.54	0.088776	84.92%	34%
2019	48648	2855.144	0.05869	85.57%	51%
2020	44524	2236.169	0.050224	67.02%	47%
2021	45330	1566.441	0.034556	46.94%	48%
2022	19045	923.4025	0.048485	27.67%	20%
Total	189465	10.415	0.280731		
Average	37893	2082.939	0.056146	62.42%	40%

Note: CPUE - catch per unit effort; TPC - fish resource utilization rate.

During the 2018-2022 period, the results show that the average utilization rate of *Rhynchobatus* spp. in WPP 712 was 62.42%. The effort level value was 40% of the optimal catch effort. This means that a 60% level of effort is needed to achieve sustainable resource utilization for *Rhynchobatus* spp.. It can be indicated that the stingray resource is at a dangerous utilization status because of overexploitation. Therefore, to preserve these resources, it is necessary to have regulations regarding their capture and use. sustainable fisheries management is compelled to achieve sustainable development objectives. Business performance and marketing strategies can dramatically change the socioeconomic and ecological results of sea resources and food from oceans.

Protection status. *Rhynchobatus* spp. caught between 2019 and 2022 recorded 27337 individuals. The stingray species that were often caught and landed in TPI on the north coast of Java have their protection status. It depends on the condition of a species in nature. The protection status of this genius is presented in Table 3.

Table 3

Protection status of stingrays landed in the Java Sea

No	*Captured species*	*Protection status*		
		Government regulations	*CITES (2021)*	*IUCN Red List (2021)*
1	Liongbun *(Rhynchobatus australiae)*	KepMen-KKP No 12 of 2022	Appendix II	Critically endangered
2	Eyebrow wedgefish (*Rhynchobatus laevis*)	KepMen-KKP No 12 of 2022	Appendix II	Critically endangered
3	Sting rays (*Rhynchobatus springeri*)	KepMen-KKP No 12 of 2022	Appendix II	Critically endangered
4	Smooth butterfly ray (*Rhina ancylostoma*)	KepMen-KKP No 12 of 2022	Appendix II	Critically endangered
5	Common guitarfish (*Glaucostegus thin*)	KepMen-KKP No 12 of 2022	Appendix II	Critically endangered
6	Stingrayray (*Glaucostegus typus*)	KepMen-KKP No 12 of 2022	Appendix II	Critically endangered
7	Ocellated eagle ray (*Aetobatus narinari*)	PerMen-KP No 61 of 2018	Appendix II	Critically endangered

Analysis of the stingray fishery management. Several stakeholders elaborated on IFAS and EFAS criteria in the management of *Rhynchobatus* spp. in the Java Sea WPP 712, which were weighed using AHP. The results are presented in Table 4.

Table 4

Matrix of IFAS calculation

No	*Questions* / *Strengths*	*Weight*	*Rating*	*Score*	*Priority*
1	Consistent production of stingrays	0.136	3	0.449072	0.180096
2	Java Sea is a place where stingrays live	0.146	4	0.519691	0.455516
3	Java Sea as the migration route for stingrays	0.132	3	0.422268	0.186876
4	The government and private sector have started to give attention to the study of stingray stocks in nature	0.151	4	0.549381	0.177512
	Subtotal	0.565		1.940412	1
	Weaknesses				
5	Low level of awareness of the fishing business actors regarding the red-list fish	0.103	3	0.257732	0.176571
6	The implementation of the regulations has not been yet effective	0.113	3	0.311856	0.27371
7	Not all catches are auctioned in Fish Auction Place	0.111	3	0.300619	0.307242
8	Information about fisheries sector data is lacking	0.107	3	0.278763	0.242477
	Subtotal	1.000		1.148969	1
	Total			3.09	

The results of the IFAS matrix (Table 4) showed that the main factor influencing internal decision-making is that the Java Sea is a place for stingrays with a value of 0.455516. Furthermore, the Java Sea is a migration route for stingrays (0.186876). Four of Indonesia's stingrays are found in the Java Sea. Another factor is the consistent production of stingrays (0.180096). Stingray catches can be found in every season. Generally, cantrang (one of the fishing gears) fishermen along the north coast of Java obtained by-catches of stingrays. However, there is a peak season, with an average catch of 5742 individuals during the west season, landed at the Fish Auction Place in the north coast of Java.

The fourth strength factor is the government and private sector attention through the study of stingray stocks in nature (0.177512) since 2019. Due to their endangered status, researchers from LIPI, IPB University, Fisheries Resources Centre Indonesia (FRCI)-Rekam Nusantara Foundation, WWF-Indonesia, BPSPL, and the Ministry of Marine Affairs and Fisheries of Indonesia conducted a collaborative study to map their populations. The results of this study are expected to be used by stakeholders as a guide to consider the pattern of sustainable management for stingrays. Therefore, in 2019, MMAF issued the Regulation the Minister of Marine Affairs and Fisheries Number 61 of 2018 and number 44 of 2019 regarding the use of protected fish and fish included in the CITES appendix, as well as the Regulation the Minister of Marine Affairs and Fisheries Number 10 of 2021 concerning standards for business activities and products in the implementation of risk-based business licensing in the maritime and fisheries factor. The newest regulation regarding quotas for catching stingrays is stated in the decree of the Minister of Marine Affairs and Fisheries number 12 of 2022.

The most dominant weakness is that not all catches are auctioned in the Fish Auction Place (0.307242). Fishermen do not conduct auctions at the Fish Auction Place because of

the "ijon" (purchasing fish before being caught) relationship with the vendors. Vendors provide capital for fishermen to go to sea, with the condition that the vendor sells the catches obtained. Furthermore, stingrays have collectors in each region who take their fins to dry and distribute to Surabaya, Jakarta, and several other big cities. Besides their fins, their meats is also used smoked. The second weakness is that implementing regulations needs to be effective (0.27371). In each Fish Auction Place on the north coast of Java, there are large posters regarding recommendations and prohibitions for catching protected fish. However, many protected stingrays, especially *Rhynchobatus* spp., need to be mature, but the catch usually consists of small rays. This problem must be monitored because *Rhynchobatus* spp. do not generally enter the auction place. The third weakness factor is that information on the data of fisheries sectors needs to be supplemented (0.242477). Information and data related to the production and catches of *Rhynchobatus* spp. in the field are difficult to obtain because the trade of stingrays in Pantura (north coast) usually has collectors who specifically buy stingrays, so catches and production of stingrays are not recorded in the Fish Auction Place. Thus, interviews with stingray sellers and collectors are required to obtain trade and production data on stingrays. The fourth area for improvement is the low awareness of fishing business actors related to the Red List of fish species (0.176571). Based on the interview results, collectors and fishermen know that fish obtained are included in the Red List or have limited trading. However, due to the economic demand, where the price per kilogram of this fish reaches up to 200 USD, the trade and catches of the fish are still carried out. *Rhynchobatus* spp. are considered by-catches with high economic value, and there needs to be awareness in the community related to their sustainability in the future.

The calculation results of the EFAS matrix (Table 5) showed that the main factor of opportunity is the many small islands used as shelter (0.444608). In the west season, many *Rhynchobatus* spp. are found near Masalembu Island, a small marine archipelago south of Borneo Island. It is presumed that stingrays take shelter from big waves. Thus, many stingrays, from puppies to adults, are found. The second opportunity factor is the condition of the Java sea waters, which is relatively stable (0.193071). The Java Sea is one of the shallow seas with the criteria of having a depth of 0-200 m. The waves in Java tend to be smaller and calmer because they are among Java, Kalimantan, and Sumatra islands. However, in a particular season, the waves reach their maximum height due to the impact of the west monsoon. The monsoon climate highly influences areas around Java Sea waters, especially the west monsoon. The third opportunity factor is the regulations regarding the stingray catch (0.181358). The Ministry of Marine Affairs and Fisheries, through the decree of the Minister of Marine Affairs and Fisheries number 12 of 2022 concerning the quotas of catch for the use of limited protected fish, has enacted the quotas of stingrays (*Rhynchobatus* spp.) in some regions, in which they can be caught when they have a minimal length of 1.7 m. The fourth opportunity factor is the high diversity of stingrays (0.180964). Indonesia is a country with global conservation, which puts it in a strategic position, particularly issues regarding the sustainability of shark and ray populations. As one of the epicenters of marine biodiversity, Indonesia makes up almost 20% of shark diversity (119 of 509 shark, and 106 of 633 ray species). Offshore species are associated with coral and sedentary species with significant shark landings. The total landing of sharks and stingrays in Indonesia reached 1.2 million tons from 2009 to 2019. According to the data from IUCN in 2015, out of 156 stingray species listed, 10 species were included in the endangered category, 3 species in the critically endangered category, 21 species in the near threatened category, 27 species in the vulnerable category, 33 species in the minor concern category, and 62 species in the deficient category (Ilham & Marasabessy 2021).

Table 5

Matrix calculation of EFAS

No	*Questions* / *Opportunities*	*Weight*	*Rating*	*Score*	*Priority*
1	The availability of regulations regarding stingray catch	0.162	4	0.589491	0.181358
2	Many small islands are used as shelter	0.146	3	0.481858	0.444608
3	The relatively stable condition of Java sea waters	0.088	2	0.176991	0.193071
4	High diversity of stingray species	0.162	4	0.589491	0.180964
	Subtotal			1.837832	1
	Threats				
5	Low gear selectivity	0.117	3	0.31073	0.281148
6	Pollution and damage to marine ecosystems	0.133	3	0.39823	0.206788
7	High market demand regarding the parts of the stingray body	0.115	3	0.299115	0.204837
8	People's perspective on the benefit of stingray body parts	0.077	2	0.135509	0.307228
	Subtotal	1.000		1.143584	1
	Total			2.981416	

The highest threat factor is the people's perspective on the benefit of stingray body parts (0.307228). Stingray fins in trade, especially of *Rhynchobatus* spp., have superior quality, so they are more expensive than other stingray fins, or even shark fins. This is because the content of stingray in their fins is higher than in shark fins, and they are believed to improve the quality of the skin, lower cholesterol, fight cancer, prevent heart problems, and improve sexual ability. Fishermen export shark fins and manta rays abroad, in China, Taiwan, Hong Kong, and Japan (Aditya & Al-Fatih 2017). The second threat factor is low gear selectivity (0.281148). The construction of fishing gear that has small meshes results in a lot of bycatch and immature fish. Furthermore, the activity of fishing gears damages marine ecosystems because they dredge the bottom of the waters and affect coral reefs, causing it to be non-selective. The third threat factor is pollution and damage to marine ecosystems (0.206788). The operation of cantrang fishing gear that dredges the ocean floor causes damage to seabed ecosystems and coral reefs as spawning grounds for fish. The last threat factor is the high demand for stingray body parts (0.204837). The decrease in the population of stingray resources is due to the high catch attempt to meet market demand for stingray fins and meat. The development of the export market to meet the demand for stingray fins causes a significant increase in the stingray catch. This is worrying in regards to the threat of species extinction in the future (Sadili et al 2015).

Alternative strategies. Alternative strategies were obtained by summing up each criterion in the IFAS and EFAS factors. The calculation results helped determine the quadrant points of the IFAS and EFAS matrix. IFAS scores are the strength aspects (1.940) and weaknesses aspects (1.149). Thus, the X-axis (from the difference between strengths and weaknesses) was 0.79. Meanwhile, the score for the opportunities aspect was 1.1838, and the threats aspect was 1.143. Thus, the Y axis (from the difference between opportunities and threats) was 0.69. The following SWOT quadrant was obtained from the X and Y axes (Figure 9).

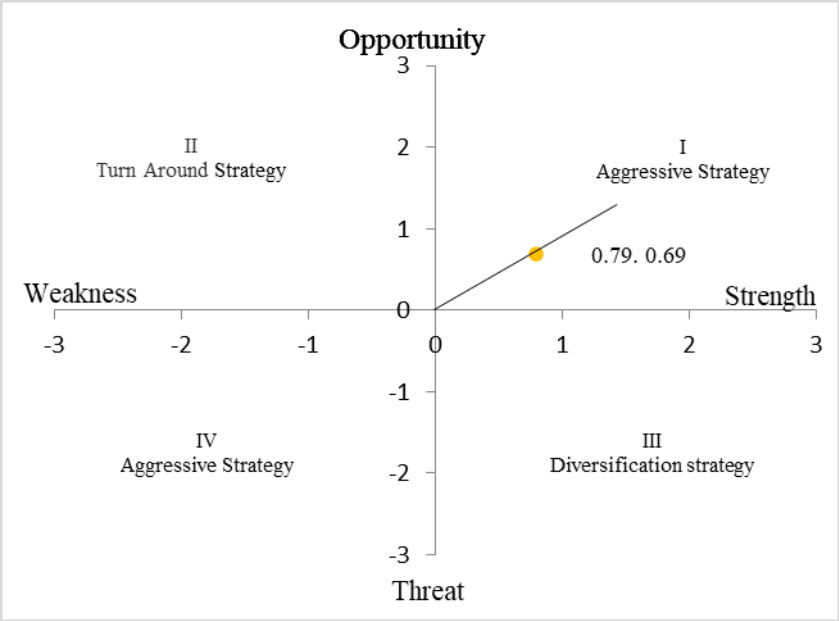

Figure 9. SWOT quadrant.

According to the SWOT matrix analysis, the four strategies were as described below.

The S-O strategy (strengths-opportunities) uses strength to utilize the opportunity. Alternative strategies that can be taken are as follows: SO1 - conducting socialization on regulations related to the size and quotas of catching protected rays by involving related stakeholders; SO2 - formulating ray conservation included in Red List and CITES I and II; SO3 - fully monitoring ray trade, specifically protected rays, either domestic or abroad; SO4 - in-depth study of the number of ray species in Indonesia related to the populations of each ray species.

The S-T strategy (strength-threat) uses strength to avoid external threats. Alternative strategies that can be taken are: ST1 - socialization and monitoring concerning environmentally friendly fishing gear in the field; ST2 - raising awareness related to preserving the sustainability of marine ecosystems and fisheries; ST3 - collecting data regarding the types of protected fish catch, especially stingray species; ST4 - optimizing the monitoring of stingray trade, either domestically and abroad.

The W-O strategy (weakness-opportunity) is a strategy to minimize a weakness by utilizing an opportunity. Alternative strategies that can be taken are: WO1 - optimizing socialization related to the regulations of fish included in the Red List; WO2 - improving facilities and infrastructure and stabilizing the price of catch in fish auction places; WO3 - raising awareness related to protected fish and handling when getting protected fish; WO4 - establishing a strong synergy among fishermen, fish auction places, and Department of Fisheries related to the protection of stingrays.

The W-T strategy (weakness-threat) is a strategy to reduce weaknesses and avoid threats. Alternative strategies that can be taken are: WT1 - optimizing sustainable and environmentally sound management of stingray fisheries; WT2 - prosecution and strict sanctions on violators for catching and exploiting protected fish species; WT3 - raising awareness related to the importance of protecting the sea and its ecosystems; WT4 - cooperating from upstream to downstream related to the protected stingray catches and disclosure of information related to stingray catches.

Determining the strategic priorities from several alternatives was carried out by referring to the calculation of the value of each factor by using the AHP analysis. Thus, the following strategic priorities were obtained.

The first strategic priority is complete monitoring of stingray trade, especially protected stingrays, domestic or abroad. In Indonesia, the utilization of fish species is regulated in the Regulation of the Minister of Marine Affairs and Fisheries Number 61/PERMEN-KP/2018 concerning the utilization of protected fish and fish listed in the

appendix of CITES. In the implementation, the government issued Regulation Number 10 of 2021 concerning the standard of business activities and products in the implementation of risk-based business licensing in the maritime and fisheries sector regarding the business standard for the utilization of catches/catching protected fish or fish included in the CITES appendix. The utilization of protected fish and fish included in the CITES appendix is regulated by licensing documents according to their utilization that is allowed or required to be separated from look-alike species.

The second strategy is formulating the conservation area of stingrays included in the Red List and CITES I and II. Act 45 of 2009 regarding fisheries article 1, paragraph 8 examines the conservation of fish resources. Therefore, in managing fish resources in Indonesia, the conservation area of protected fish is required for the importance of science, culture, fish tourism, or the sustainability of fish resources and the environment. The study results showed that areas around small islands and Masalembu are the most appropriate areas to be designed as conservation areas for *Rhynchobatus* spp.

The third strategy is strengthening the role of fishermen's organizations or groups. Several programs were carried out by the Department of Fisheries in Cilacap Regency to improve the role of organizations, with socialization and development of a network in fishermen associations, especially border fishermen. The programs aimed to help solve fishermen's problems by deliberation, so that the development of sustainable and responsible fisheries could be realized.

The fourth strategy is an in-depth study of the number of ray species in Indonesia related to the populations of each ray species. Referring to the regulation of CITES, determining Sting rays (*Rhynchobatus spp*) as fish species in Appendix II, where this species is still allowed to catch in limited quantities to maintain the existence of Sting rays (*Rhynchobatus spp*) in nature.

Conclusions. Utilization of stingrays (*Rhynchobatus* spp.) resources in the Java Sea reaches 62.4%. This shows that stingrays are vulnerable to overexploitation. Furthermore, the species of family Rinidae caught in the Java Sea are included in the Appendix II, where, in their utilization, they must be monitored to avoid extinction. Thus, alternative strategies that can be used are: the socialization regarding the size and quotas for catching protected stingrays; formulating a conservation area of stingrays included in the Red List and CITES I and II; thorough monitoring of stingray trades, especially protected stingrays, domestically or abroad; in-depth study of the number of stingray populations in Indonesia.

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References

Aditya F. Z., Al-Fatih S., 2017 Legal Protection of Sharks and Stingrays to Maintain the Balance of Indonesia's Marine Ecosystems. Legality 24(2):224-235. [In Indonesian].

Dsikowitzky L., Damar A., Ferse S. C. A., Irianto H. E., Jennerjahn T. C., Lukas M. C., Nordhaus I., Pohlmann T., Schwarzbauer J., Sugama K., Sumiono B., 2019 Java Island, Indonesia. In: World seas: An environmental evaluation. 2nd Edition. Academic Press, pp. 459-490.

Hakim l. l., Anna Z., Junianto, 2014 Bioeconomic analysis of narrow-barred Spanish mackerel (*Scomberomorus commerson*) in the water of Indramayu Regency West Java. Journal of Marine and Fisheries Socio-Economic Policy 4(2):117-127. [In Indonesian].

Hartoko A., Helmi M., 2004 Development of digital multilayer ecological model for Padang coastal waters (West Sumatra). Journal of Coastal Development 7(3):129-136.
Henríquez-Antipa L. A., Cárcamo F., 2019 Stakeholder's multidimensional perceptions on policy implementation gaps regarding the current status of Chilean small-scale seaweed aquaculture. Marine Policy 103:138-147.
Hue H. T. T., Pradit S., Lim A., Goncalo C., Nitiratsuwan, T., 2018 Shrimp and fish catch landing trends in Songkhla lagoon, Thailand during 2003-2016. Applied Ecology and Environmental Research 16(3):3061-3078.
Ilham, Marasabessy I., 2021 [Identification of types and conservation status stingray traded out of Sorong City at the resource management Loka Sorong Coast and Sea]. Jurnal Riset Perikanan dan Kelautan 3(1):290-302. [In Indonesian].
Imelda, Kusrini N., Hidayat R., 2019 [Strategy of sustainable coastal fisheries management in Kubu Raya Regency]. Marine Fisheries 10(1):59-69. [In Indonesian].
Jabado R. W., 2019 Wedgefishes and giant guitarfishes: A guide to species identification. Wildlife Conservation Society, New York, 30 p.
Kinakesti S., Wahyudewantoro W., 2017 [Study of stingray types (Dasyatidae) in Indonesia]. Jurnal Fauna Indonesia 16(2):17-25. [In Indonesian].
Kurniawati F., Sanjoto T. B., Juhadi, 2015 [Estimation of small pelagic fishing potential zones in the Java Sea waters in the west and east seasons using aqua modis imagery]. Geo Image (Spatial-Ecological-Regional) 4(2):9-19. [In Indonesian].
Kusrini, Aba, 2019 [Anatomical structure of the intestinal valvula of guitar rays]. Jurnal Florea 6(1):20-27. [In Indonesian].
Latukonsina H., 2010 [Estimating the potential and level of utilization of flying fish (*Decapterus* spp) in Flores Sea waters, South Sulawesi]. Jurnal Ilmiah Agribisnis dan Perikanan 3(2):47-55. [In Indonesian].
Oktaviani S., Kurniawan W., Fahmi, 2020 [Species composition and size distribution of sharks and rays caught in the Bali Strait and surrounding waters and their relation to fisheries management]. Indonesian Journal of Ichthyology 20(1):23-46. [In Indonesian].
Sadili D. F., Dharmadi S., Ramli I., 2015 [The manta: manta sightings in Manta Sandy - Raja Ampat West Papua Indonesia]. Jurnala Ilmu dan Teknologi Kelautan Tropis 11(1):117-122. [In Indonesian].
Satiati N., Lestari, A. N., Partaya & Priyono B. 2020. Assessment of Biological Aspects and Extinction Status of Stingrays traded at the Central Java North Coast fish auction site. 693-679.
Simeon B. M., 2019 [General overview of wedgefish and giant guitarfish in Indonesia. Research report]. Wildlife Conservation Society (WCS), Bogor, Indonesia, 54 p. [In Indonesian].
White W. T., Last P. R., Stevens J. D., Yearsley G. K., Dharmadi F., 2006 Economically important sharks and rays of Indonesia. ACIAR, Canberra, 338 p.
Wijayanti F., Pandu A. M., Fitriana, N., 2018 [Species diversity and conservation status of stingrays at the Muara Angke fish auction site, North Jakarta]. Jurnal Biodjati 3(1):23. [In Indonesian].
Yuwandana D. P., Agustina S., Haqqi M. B., Simeon B. M., 2019 [Preliminary study of the kekeh Ray (*Rhynchobatus* sp.) and stingray (*Glaucostegus* sp.) fisheries in the northern waters of Central Java]. Jurnal Akuatikan Indonesia 5(1):1-6. [In Indonesian].
Yuwandana D. P., Pranata I. A. W., Agustina S., Hartati I. D., Muttaqin E., Simeon B. M., 2020 [Fishery status of weasel rays (Rhinidae) and file rays (Glaucostegidae) in the northern waters of Java]. Rekam Nusantara Foundation, 43 p. [In Indonesian].
*** gebco.id
*** IUCN, 2015 IUCN Red List of threatened species. Available at: http://www.iucnredlist.org/
*** Kyne P. M., Rigby C. L., Dharmadi, Jabado R. W., 2019 *Rhynchobatus australiae*. The IUCN Red List of Threatened Species 2019.
*** Law of the Republic of Indonesia, 2009 Law No. 45 of 2009 concerning fisheries.

*** Marine and Fisheries Ministry, 2018 Regulation of the Minister of Maritime Affairs and Fisheries Number 61/PERMEN-KP/2016 concerning the utilization of protected fish types and/or fish types listed in the appendix to the Convention on International Trade in Endangered Species of wild fauna and flora.
*** Marine and Fisheries Ministry, 2019 Decree of the Minister of Maritime Affairs and Fisheries Number 12/PERMEN-KP/2022 Concerning harvest quotas for limited use of protected fish species based on national provisions and fish types in Appendix II of the Convention on International Trade in Endangered Species of wild fauna and flora.
*** Marine and Fisheries Ministry, 2019 Regulation of the Minister of Maritime Affairs and Fisheries Number 44/PERMEN-KP/2019 concerning the utilization of protected fish types and/or fish types listed in the appendix to the Convention on International Trade in Endangered Species of wild fauna and flora.
*** Marine and Fisheries Ministry, 2021 Regulation of the Minister of Maritime Affairs and Fisheries Number 10/PERMEN-KP/2021 about business activity and product standards in the implementation of risk-based business licensing in the marine and fisheries sector.
*** Marine and Fisheries Ministry, 2022 Decree of the Minister of Maritime Affairs and Fisheries Number 12/KEPMEN-KP/2022 Concerning harvest quotas for limited use of protected fish species based on national provisions and fish types in Appendix II of the Convention on International Trade in Endangered Species of wild fauna and flora.

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