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ECONOMIC BENEFITS AND GOVERNANCE OF GUIDING BARRIER FISHING GEAR IN WHITE-SPOTTED SPINEFOOT FISH FISHING ACTIVITIES (*Siganus canaliculatus*, Park 1797) IN BONTANG CITY WATERS

MANFAAT EKONOMI DAN KEBIJAKAN TATA KELOLA ALAT TANGKAP BELAT PADA AKTIVITAS PENANGKAPAN IKAN BAWIS (*Siganus canaliculatus*, Park 1797) DI PERAIRAN KOTA BONTANG

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ABSTRACT

Guiding barrier fishing gear has been used in recent years in the mangrove, seagrass, and coral ecosystem areas of Bontang City. In previous studies, the main target, white-spotted spinefoot fish, has depreciated and degraded as a result of overfishing. This study calculates the economic benefits and attempts to analyze the management policy of guiding barrier fishing gear to overcome the depreciation and degradation problems. To calculate the economic benefits, the fisheries production approach was used, while the policy analysis used the interpretive structural model technique. During the peak season of white-spotted spinefoot fish, the average fisherman earns up to IDR400,750 per day, with a minimum of IDR103,000 and a maximum of IDR1,904,000. The optimal fishing period is nine months, after which fishermen will stop fishing in Ramadan, August, and September. There are six guiding barrier fishing gear management policies, namely: 1) open and close systems at the installation site; 2) increase the mesh size used; 3) reduce the number; 4) moratorium on new installations; 5) limit the number of owners for each fisherman; and 6) regulate the distance between guiding barrier fishing gear. Of the six policy alternatives, the top priority is to increase the mesh size used.

Keywords: fisheries governance, white-spotted spinefoot fish, guiding barrier fishing gear, Bontang City waters.

ABSTRAK

Penangkapan ikan menggunakan alat tangkap belat digunakan dalam beberapa tahun terakhir di kawasan ekosistem mangrove, lamun, dan karang Kota Bontang. Penelitian sebelumnya, ikan bawis yang menjadi target utama telah mengalami depresiasi dan terdegradasi sebagai akibat penangkapan berlebih. Penelitian ini menghitung manfaat ekonomi dan berupaya menganalisis kebijakan tata kelola alat tangkap belat untuk mengatasi masalah depresiasi dan degradasi. Untuk menghitung manfaat ekonomi menggunakan pendekatan produksi perikanan, untuk analisis kebijakan menggunakan teknik *Interpretive Structural Model.* Saat musim puncak ikan bawis, rata-rata nelayan memperoleh keuntungan hingga Rp400.750 per hari, minimum Rp103.000 dan maksimum Rp1.904.000. Masa penangkapan optimal selama sembilan bulan, nelayan akan berhenti melaut pada bulan Ramadhan, Agustus, dan September. Terdapat enam kebijakan tata kelola belat yaitu: 1) sistem buka tutup pada lokasi pemasangan, 2) meningkatkan ukuran mata jaring yang digunakan, 3) mengurangi jumlah, 4) moratorium pemasangan baru, 5) membatasi jumlah kepemilikan untuk setiap nelayan, dan 6) mengatur jarak antar alat tangkap belat. Dari enam alternatif kebijakan tersebut, prioritas utama adalah meningkatkan ukuran mata jaring yang digunakan.

Kata kunci: tata kelola perikanan, ikan white-spotted spinefoot fish, alat tangkap belat, perairan Kota Bontang.

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INTRODUCTION

Bontang City's sea waters have shallow and sloping topographic characteristics. The aquatic environment consists of groups of islands, gusungs, and shallows that are habitats for corals, seagrasses, and mangroves, which form an ecosystem. These conditions are able to maintain the stability of the coast and the resources within it, so that they are able to support business activities for the people of Bontang City. Sulistianto *et al*., (2022) revealed in their research that the economic value of the coastal area of Bontang City reached IDR 115.72 trillion per year. The seagrass ecosystem is an ecosystem that can be found in the water environment of Bontang City. Seagrass beds have an important role in maintaining fish stocks because coral fish generally carry out ontogenic migration to support their life cycle, starting from the larval, juvenile, and immature stages in the seagrass meadow ecosystem (Latuconsina *et al*., 2023).

The seagrass area of Bontang City reaches 13,990.8 ha (Oktawati *et al*., 2018, 2019). In this area, 112 types of fish can be found. Of the total, there are 10 types of fish that dominate, namely: 1) *Gerres flamentous*, 2) *Siganus doliantus*, 3) *Apogon kiensis*, 4) *Lethrinus lentjan*, 5) *Siganus canaliculatus*, 6) *Apogon kallopterus*, 7) *Lutjanus fulvus*, 8) *Siganus guttatus*, 9) *Pentapodus bifasciatus*, and 10) *Stolephorus indicus* (Irawan *et al*., 2018). *Siganus canaliculatus* is one of the ten types of fish that dominate the seagrass ecosystem and has been used as a fishing target by fishermen in Bontang City. Sulistianto *et al*., (2022) revealed that the seagrass ecosystem in Bontang City provides benefits for capture fisheries activities. The fish that is mostly caught in the seagrass ecosystem is Siganus canaliculatus. Local fishermen call it white-spotted spinefoot fish. White-spotted spinefoot fish has stable prices and tends to experience price increases. Apart from that, the demand for this type of fish is high because it is on the main menu in restaurants for the typical Bontang dish, namely Gami White-spotted spinefoot fish. This dish can be on the menu of choice for tourists in Bontang City. The Bontang Marove Park tourist location is equipped with a food court, which has a contribution of up to Rp 30,000,000 per month to service providers (Safri et al., 2022). Apart from that, white-spotted spinefoot fish is popular with the public because it has a very soft meat texture, a delicious taste, and a high nutritional content (Sitepu *et al*., 2018).

White-spotted spinefoot fish are endemic seagrass fish that are often found in seagrass ecosystem areas. The presence of white-spotted spinefoot fish has an important role in maintaining the stability of the seagrass ecosystem in Bontang City (Oktawati *et al*., 2019). White-spotted spinefoot fish are caught in seagrass areas using *belat* (local name) or *sero* fishing gear. This fishing gear is spread in shallow waters and can be found from the waters north to the waters south of Bontang City. Based on the results of the observations made, guiding barrier fishing gear was installed in the seagrass area. The *penaju* (leader net) extends across the seagrass area, and then the bag is on the edge of the seagrass area, close to the pool (lagoon), or in an area where seagrass does not grow. Badan Pusat Statistik Kota Bontang (2020) stated that the total catch of white-spotted spinefoot fish reached 2,431.34 metric tons; this number has decreased compared to 2019, which reached 2,566.94 metric tons. This number is much different when compared to other types of fish;

the only type of fish that is close to the total catch of white-spotted spinefoot fish is the gray tuna, namely 2,072.21 metric tons. This indicates that white-spotted spinefoot fish are the main contributor to the total marine fish catch by type in Bontang City.

The development of white-spotted spinefoot fish catches has increased significantly compared to 2010 and 2020; however, within this time period, the increase has fluctuated. Data shows that the highest catch was in 2017, which reached 3,206.59 metric tons, and then until 2020, the catch continued to decline. Furthermore, if we look at fishing effort, the correlation between fishing effort and catch is negative. For example, in 2017, arrest attempts ranged from 18,960 attempts, continuing to increase to 23,178 attempts. This condition does not match the results captured with the efforts made (BPS Kota Bontang, 2020).

White-spotted spinefoot fish resources are the main resource for fishermen to maintain their income. The result is that the efforts made by fishermen to catch white-spotted spinefoot fish continue to increase. Increasing fishing efforts will have a negative impact on fish populations and seagrass as their habitat. The negative impact in question is that the whitefish population will experience a decline, and the seagrass will experience damage due to the installation of guiding barrier fishing gear. The habitat of white-spotted spinefoot fish is in seagrass beds, and the relationship between the two is very close to supporting human welfare. The high effort of fishermen to catch white-spotted spinefoot fish has an impact on ecological pressure in seagrass beds, resulting in a decline in white-spotted spinefoot fish populations (Jailani, 2006; Rohmawati *et al*., 2015; Wahyudin *et al*., 2016). Recent research conducted by Oktawati *et al*. (2019) revealed that since 2013, white-spotted spinefoot fish resources have begun to show signs of degradation and depreciation. This research seeks to analyze the economic benefits and what policies need to be implemented to maintain white-spotted spinefoot fish resources so that they are not degraded and depreciated. The research results are important to provide information regarding the economic benefits obtained by fishermen and appropriate policies for carrying out management actions so that fishing activities can continue without degrading and depreciating white-spotted spinefoot fish resources.

RESEARCH METHODS

Research began in August 2022 using primary data; samples were taken using non-probability sampling techniques. This technique is a sampling procedure that does not pay attention to the rules of probability, so it depends on the policy, experience, and subjectivity of the researcher. The type of sampling used is purposive sampling, where this type is used when the sample is taken based on a definite assessment (expert judgment) regarding the population as a whole (must have sufficient knowledge about the population). The total sample consisted of 30 fishermen who used guiding barrier fishing gear to find out the economic benefits and seven expert respondents who understood issues related to fishing using guiding barriers to find out alternative governance policies. The expert respondent component consisted of two fisheries supervisors from the Food, Agriculture, and

Fisheries Service of Bontang City, two people from the Tanjung Limau Fisheries Harbor UPT, Bontang City, two academics from the Faculty of Fisheries and Marine Sciences at Mulawarman University, and one local NGO. Primary data was obtained through two stages, namely: 1) an in-depth interview stage to obtain policy alternatives; and 2) a weighting and comparison of the level of importance for each policy alternative.

Economic benefit data is analyzed using a production and market price approach (Auliansyah *et al*., 2021). The net profits that fishermen make from their fishing-related businesses can be considered economic benefits. Profits are calculated through stages; the first stage is calculating the total costs using the equation (Samuelson & Nordhaus, 2010).

$$TC = FC + VC \quad (1)$$

TC = *Total Cost*; FC = *Fixed Cost* dan VC = *Variabel Cost.* The next step is to calculate total revenue using the following equation (Samuelson & Nordhaus, 2010) :

$$TR = P.Q \quad (2)$$

TR = *total revenue*, P = the price of each type of fish caught, Q = the number of each type of fish caught on each trip. Finally, profits are calculated using the equation for the price of each type of fish caught (Samuelson & Nordhaus, 2010).

$$\pi = TR - TC \quad (3)$$

Data to determine alternative policies for managing guiding barrier fishing gear were analyzed using the Interpretative Structural Modeling (ISM) technique. ISM is a modeling technique developed to develop planning policy strategies (Marimin, 2004). ISM application requires eight stages (Kanungo & Bhatnagar, 2002; Sushil, 2012) namely: 1) identification of elements and sub-elements through in-depth interviews; 2) formulation of contextual relationships between elements; 3) formulation of a single structured interaction matrix (Structural Self-Interaction Matrix/SSIM) through expert surveys, 4) changing the SSIM matrix to a Reachability Matrix (RM) and then to a binary matrix, 5) Classification of elements into tiered levels, 6) Canonical Matrix: grouping elements at the same level, 7) Compiling a digraph matrix is a concept that comes from the directional graph, a graph of elements that are directly interconnected at a hierarchical level, and 8) Interpretive Structural Model: ISM is generated by moving the entire number of elements with actual element descriptions. The analysis stage uses EXsimpro software.

SSIM represents each expert's perception of each specified policy element or alternative. Each element is compared for its level of importance using the symbols V, A, X, and O.

V = if the left sub element is more important than the top sub element

A = if the top sub element is more important than the left sub element

X = if the top sub element is as important as the left sub element

O = if the top sub element is not related to the left sub element

The conversion rules from the Structural Self-Interaction Matrix/SSIM symbol to the Reachability Matrix/RM are applied as follows:

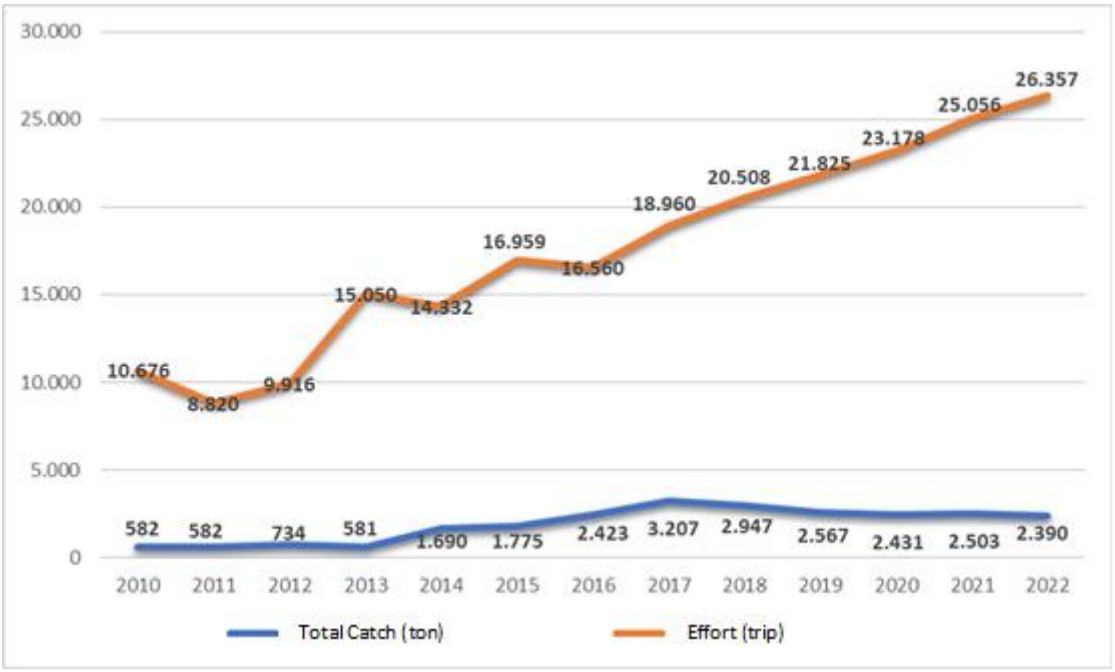
1) If the relationship of E_i to E_j = V in SSIM, then element E_{ij}= 1 and E_{ji} = 0 in RM;

2) If the relationship of E_i to E_j = A in SSIM, then element E_{ij}= 0 dan E_{ji} = 1 in RM;
3) If the relationship of E_i to E_j = X in SSIM, then element E_{ij}= 1 dan E_{ji} = 1 in RM;
4) If the relationship of E_i to E_j = O in SSIM, then element E_{ij}= 0 dan E_{ji} = 0 in RM;

RESULTS AND DISCUSSION

Economic Benefits of White-spotted spinefoot fishing Business

The economic value of the coastal area of Bontang City reaches IDR 115.72 trillion per year. This value is obtained from the ecosystem services of coral reefs, seagrass, and mangroves, which are used as areas for capture fisheries, fish farming, seaweed cultivation, recreation, coastal protection, ecological, and educational functions (Sulistianto *et al*., 2022). Specifically for capture fisheries, based on marine fisheries production by type, baronang lingkis, or white-spotted spinefoot fish, is a fishery commodity that contributes the most when compared to other types of fish. In 2022, total production will reach 2,390.40 tons; this number is far above other types of fish, such as skipjack, 1,794.10 tons (BPS Kota Bontang, 2023). However, compared to 2021, production results in 2022 will decrease. White-spotted spinefoot fishing data is presented in Figure 1.



Source: Badan Pusat Statistik Kota Bontang (2023)

Figure 1. White-spotted spinefoot fish Catch Data for 2010 – 2023

The development of white-spotted spinefoot fish catches in Figure 1 shows a significant increase when compared to 2010 and 2022; however, within this time period, the development has experienced fluctuations. Data shows that the highest catch was in 2017, which reached 3,207 metric tons, and then until 2022, the catch decreased. Even though there has been a decline, catches are still higher compared to 2010–2016. Furthermore, if we look at fishing effort, the correlation between fishing effort and catch is negative. This can be proven: in 2013, there was an increase in fishing attempts of 15,050 compared to 9,916 in 2012; however, catches actually decreased. The catch in

2012 was 734 tons, which decreased to 581 tons in 2013. On the other hand, in 2014, the effort decreased but the catch increased very significantly. If you look in more detail, the data shows that if there is a decrease in fishing effort, the results obtained will increase, meaning that the White-spotted spinefoot fish population will increase if the fishing effort is reduced. The increase in fish population occurs because the fish have space or time to breed or reproduce before being caught. The increasing fish population will have a significant impact on catch results.

The number of fishermen using guiding barrier fishing gear in Bontang City has reached 60. This research interviewed 30 fishermen. Interview results show that fishermen have at least two units of guiding barrier fishing gear, a maximum of 26 units. The complete distribution of guiding barrier fishing equipment ownership for each fisherman is presented in Table 1.

Table 1. Distribution of Guiding barrier Ownership per Fisherman

Number of Guiding barrier Ownership Per Fisherman (Unit)	Frequency (person)	Percentage (%)
2	1	3
3	1	3
5	8	27
6	5	17
7	8	27
8	1	3
9	2	7
10	1	3
12	1	3
15	1	3
26	1	3
Total	**30**	**100**

Source: Interview result (2022)

Based on Table 1, it shows that fishermen who own 5 and 7 units of guiding barrier fishing gear each have eight people, or the equivalent of 27%; six units have five people; nine units have two people; and the other numbers have one person each. The costs incurred by each sting fisherman depend on the number of guiding barriers owned, installation location, boat, and type of machine used.

If viewed from the perspective of financing by fishermen, this research divides two types of costs, namely fixed costs and variable costs. Table 2 presents the costs that each fisherman incurred in detail.

Table 2. Costs Incurred by Fishermen Using Guiding barriers

	Fixed Costs (IDR)	Non-Fixed Costs (IDR)
Average	16,550,000	345,500
Minimum	11,500,000	190,000
Maximum	27,000,000	930,000

Source: Interview result (2022)

Fixed costs include the procurement of boats, engines, fish storage containers, and fishing gear guiding barriers, while non-fixed costs include fuel oil, food and drink, maintenance costs for engines, boats, and fishing gear, distribution costs for catches, and ice cubes. From these costs, fishermen can obtain the income presented in Table 3. Each fisherman catches an average of 1.18 kg of whitefish for each guiding barrier fishing gear and an average of 1.14 kg for mixed fish such as

snapper, ketamba, grouper, rakulu, squid, and various other types of fish. Minimum 1 kg white-spotted spinefoot fish and mixed fish, and maximum 2 kg white-spotted spinefoot fish and 2.5 kg mixed fish.

Table 3. Income of Belt Fishermen

	Catch		Selling Price per Kg			
	White-spotted spinefoot fish (Kg)	Mixed Fish (Snapper, Ketamba, Grouper, Trakulu, Squid, etc.) (Kg)	White-spotted spinefoot fish (IDR/Kg)	Mixed Fish (Snapper, Ketamba, Grouper, Trakulu, Squid, etc.) (IDR/Kg)	Receipts per IDR/Trip	Profit IDR/Trip
Average	1.18	1.14	41,167	47,713	746,250	400,750
Minimum	1	1	30,000	23,333	355,000	103,000
Maximum	2	2,50	50,000	73,333	2,834,000	1,904,000

Source: Interview result (2022)

The results of guiding barrier catches can vary; the results are determined by the physical conditions of the waters and the surrounding marine ecosystem. As in the results of research conducted by Rosadi *et al* (2022), the guiding barrier fishing gear installed in the estuary waters of the fish obtained was dominated by the Johnius trachycephalus type. However, if the guiding barrier is installed in a water area that has a complete marine ecosystem (mangrove, seagrass, and coral), then the types of catch will be more diverse, as in the results of this study and Rohmawati *et al* (2015), there are 15 species. This occurs because of the high connectivity of mangrove, seagrass, and coral reef ecosystems in supporting various biological activities of ichthyofauna communities (Latuconsina *et al*., 2023).

The selling price of white-spotted spinefoot fish is an average of IDR 41,167 per kg, a minimum of IDR 30,000 per kg, and a maximum of IDR 50,000 per kg. Mixed fish averages IDR 47,713 per kg, minimum IDR 23,333 per kg, and IDR 73,333 per kg. If you look in more detail, the selling price of mixed fish is more expensive than the price of white-spotted spinefoot fish. In general, the catch is sold to collectors, but there are also fishermen who sell it to the market. When the fishing season is at its peak, the average profit for each fisherman reaches IDR 400,750 per trip, a minimum of IDR 103,000 per trip, and can even reach IDR 1,904,000 per trip. The more guiding barriers a fisherman has, the greater his income opportunities will be. Like fishermen who earn IDR 1,904,000 per trip because they have 26 units of guiding barrier fishing gear. When compared with the research results of Nazwan *et al* (2019), during the fish harvest season, the average profit for fishermen can reach IDR 9,619,000 per month. If this value is divided by 26 days, it is equivalent to IDR 370,000.

Figure 2 depicts the types of fish that guiding barriers can catch. Looking at Figure 2, for the type of white-spotted spinefoot fish, the size of the fish caught is very diverse; this condition is the same as for the types of groupers, snapper, rakulu, white fish, and other mixed fish. has a relatively small size and can still grow larger. This condition is caused by the mesh size used in the guiding barrier, which ranges from 1.5 to 2 inches.

White-spotted spinefoot fish

Grouper

Grouper

Squid

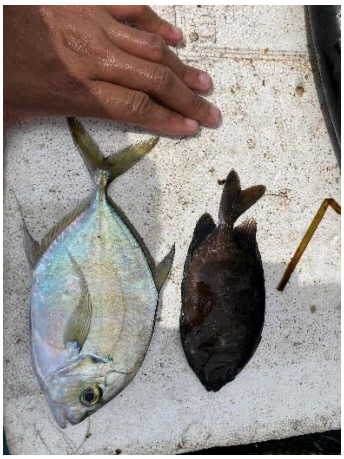
Ketamba

Snapper

Trakulu

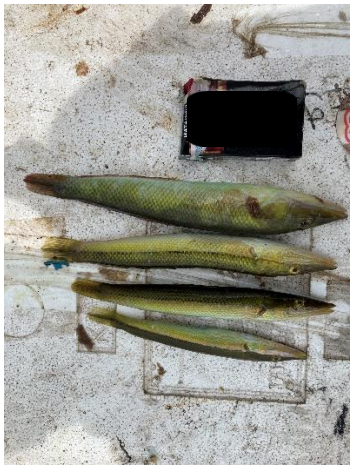
Crab

Crab



White fish and Baronang

Other mixed fish



Other mixed fish

Tompel Fish

Grouper

Grouper

Source: Research Documentation (2022)

Figure 2. Types of Fish Caught in Guiding barrier Fishing Gear

Guiding barrier Gear Management Policy

Identification of policy alternatives occurs in two stages. First, in-depth interviews were conducted with seven experts. Second, confirm and validate the interview results. As a result of interviews conducted with experts, six alternative policies were obtained for managing the guiding barrier fishing gear in the waters of Bontang City. Policy alternatives are presented in Table 4 as follows:

Table 4. Alternative policies for Guiding barrier Fishing Gear Management

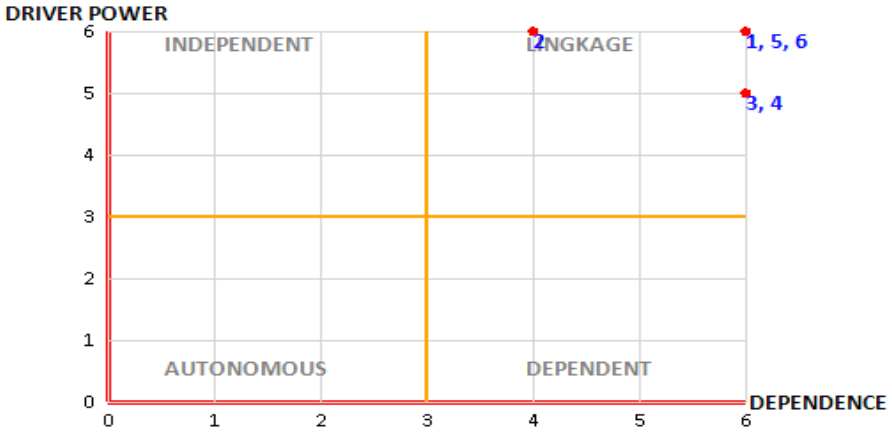
Policy Alternative Code (Element)	Policy Alternatives
E1	Open and close system at installation location
E2	Increase the size of the mesh used
E3	Reducing the number of Guiding barrier fishing gear
E4	Moratorium on the installation of new Guiding barrier fishing gear
E5	Limiting the number of Guiding barrier fishing gear ownership for each fisherman
E6	Set the distance between the guiding barrier fishing gear

Source: Expert Interview Results (2022)

After obtaining policy alternatives, the next stage in this analysis is the formulation of contextual relationships between policy elements. The results of formulating contextual relationships between policy elements can be seen in Figures 3 and 4. Figure 3 is a graph that is divided into four quadrants,

namely autonomous, dependent, independent, and linked. Autonomous is defined as the quadrant that has high power of influence; dependent is replaced by the quadrant that has low power of influence and high dependency; linkage is defined as the quadrant that has both high power of influence and high dependency; and independent is defined as having high power of influence and low dependency. The results of formulating contextual relationships between policy elements in Figure 3 show that all policy elements are in the Lingkage quadrant, meaning that all policy elements have high influence but also have high dependence on other policy elements.

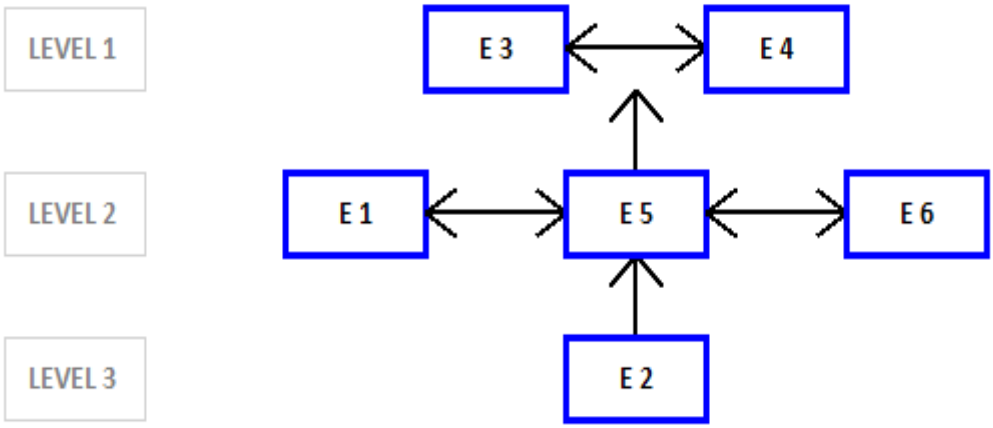
Six policy alternatives can be chosen to overcome the problem of degradation and depreciation of white-spotted spinefoot fish resources. However, of the six existing policy alternatives, increasing the mesh size is the alternative with the strongest incentive to overcome the problem, so that if implemented, the other policies can be implemented gradually or cannot be implemented if the policy of increasing the mesh size is successful and has an impact on increasing the population and size of fish caught.



Source: Data Analysis Results (2022)

Figure 3. Graph of Governance Policy Elements for Guiding barriering Equipment

The results of the next analysis are the results of the Reachibility Matrix (RM). The RM results are divided into structures based on levels, or what is usually called level structure. Figure 3 shows two arrow directions; the upward arrow means that the policy element produces the factors above it, while the two-way arrow to the side means they influence each other in producing the factors above it, in other words, the higher the level produced, the highest level is the key element and becomes the driving force for other policy elements. Figure 4 shows that E2 (increasing the mesh size used in guiding barrier fishing gear) is a key policy element. In the case of Guiding barrier fishing gear fisheries governance, experts prioritize policy E2, then policy elements E1, E5, and E6. The final policy elements are E3 and E4. In this case, level 3 is the highest level. This means that policy alternatives or elements at this level are key policies that can be implemented because they have a strong driving force, so other policy alternatives can be implemented gradually or not if the policy at level 3 is successfully implemented.



Source: Data Analysis Results (2022)

Figure 4. Level Structure Elements of Guiding barrier Fishing Gear Governance Policy

CONCLUSION AND SUGGESTION

Conclusion

The economic benefits obtained by fishermen using guiding barrier fishing gear are an average of IDR 400,750 per trip, a minimum of IDR 103,000 per trip, and a maximum of IDR 1,904,000 per trip from an average number of 9 units of guiding barriers. Six policies for managing guiding barrier fishing gear were found, including: 1) implementing an open and close system at locations where guiding barrier fishing gear is installed; 2) increasing the mesh size used in guiding barrier fishing gear; 3) reducing the number of guiding barrier fishing gear; and 4) placing a moratorium on installing new gear. catch guiding barriers, 5) limit the number of guiding barrier fishing gear owners for each fisherman, and 6) regulate the distance between guiding barrier fishing gear. Even though there are six policies, based on the results of the ISM analysis, experts prioritize the policy of increasing the mesh size used in guiding barrier fishing gear.

Suggestion

In order to ensure the preservation of white-spotted spinefoot fish resources and several other types of fish, as well as the economic benefits felt by fishermen, the East Kalimantan Province Maritime and Fisheries Service and various interested parties should encourage a policy of increasing the size of nets used in guiding barrier fishing gear.

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