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ANALYSIS OF PRIORITY INDICATORS THAT AFFECT THE EFFECTIVENESS OF THE PURSE SEINE USING ANALYTICAL HIERARCHI PROCESS (AHP) IN INDONESIA

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ABSTRACT

Research on indicators that affect the effectiveness of purse seine has been carried out and is only limited based on known operations and the weight of each indicator is not yet known. Therefore, the purpose of this study is to analyze the weighting of indicators that determine the effectiveness of purse seine operations. In achieving the goal, the primary data collected is data on the completeness of purse seine fishing gear, operating aids, vessels and fishing lanes by means of observation using a questionnaire to 10 respondents. Then, secondary data which includes statistical data on arrests obtained from the Ministry of Maritime Affairs and Fisheries. Analysis of the data used is descriptive analysis of the catch, analysis of the effectiveness of fishing gear, and analytic hierarchical process (AHP). The order and weighting of the indicators that affect the effectiveness of purse seines is the mesh size of the purse seine bag which has a weight of 3 in the very priority category, the power of the lights and the length of the upper rope (weight 2, priority category), FADs and their identification tags, ship size and flight path. Fish (weight 1, moderately priority category) and the last order is radar reflector weight 0 with non-priority category. In conclusion, based on the order of weighting, there is 1 indicator having a weight of 3, 2 indicators having a weight of 2, 3 indicators having a weight of 1 and 1 indicator having a value of 0. Each weighting can be applied in the application of industrial-scale fishing gear monitoring.

Keywords: Effectiveness, Indicator, Purse Seine, Ranking.

1 INTRODUCTION

Indonesia have dominant fishing potential [1], The lack of evaluation of the effectiveness of purse seines is an ongoing problem in fisheries management. Evaluation of the effectiveness of purse seines is usually carried out on the type, specifications of fishing gear and production of catches at the fishing base. Increased catch will increase effectiveness. Fishermen prefer fishing gear that has high effectiveness, because it can reduce operational costs [2]. Several factors that affect the effectiveness of purse seines are operating time, boat speed, fishing gear construction [3]. Two of the easiest ways for fishermen to increase effectiveness are to change the mesh size of the codend to a smaller than standard and fishing area that is not on track. Fishermen operate purse seines in fishing lanes I which should be in fishing lanes II and III [4]. This discrepancy in the use of fishing gear and fishing paths must be evaluated according to regulations so that the status of the purse seine fishery can be sustainable.

Several studies that are relevant to the research have been carried out. [5] examined the suitability of the purse seine construction sizes used by Batam fishermen based on SNI number 8186:2015. Others, [6] determined the characteristics of purse seine fishing gear at PPI Alok, Alok District, Sika Regency using a descriptive method. [7] examined the suitability of fishing gear types in the Misool traditional use zone, Raja Ampat using AHP. Then, [8] also analyzed the policy analysis of purse seine fishery development using the Analytical Hierarchical Process (AHP) method in the waters of Parigi Moutong Regency with 8 established criteria, namely fish resource potential, technology, facilities and infrastructure, human resources, market potential, investment capability, as well as product quality and price.

The weakness of the aforementioned studies is that they only determine criteria based on sustainability aspects and have not determined the weight of each indicator. Whereas priority indicators that affect the effectiveness of purse seine operations have complex aspects [9]. Determination of the main indicators and their weights can be used as a reference in determining the suitability of fishing units when monitoring by related parties.

Therefore, the purpose of this study is to analyze the priority indicators that determine the effectiveness of purse seine operations. The novelty of this research is that the indicators determined refer to the Minister of Marine Affairs and Fisheries Regulation number 18 of 2021 by considering the sustainability aspect. The results of the study can be used as the basis for determining monitoring and evaluation policies for purse seine fisheries and maintaining the sustainability of sustainable fish resources. The value of each indicator can be applied in the application of monitoring the suitability of industrial-scale fishing gear.

2 MATERIAL AND METHODS

2.1 Data

Table 1: Analytical Hierarchy Process (AHP) Questionnaire and its importance scale.

1.	**Criteria 1**									**Criteria 2**						
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
2.	**Criteria 2**									**...**						
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
3.	**Criteria 3**									**...**						
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Description Intensity of interest:

1	=	Equally important;	6	=	Between important and very important;
2	=	Between equally important and more important;	7	=	Very important;
3	=	More important;	8	=	between very important and most important once;
4	=	Among the more important and important;	9	=	Most Important Once.
5	=	Important;			

The primary data in this study were data on the completeness of purse seine fishing gear, operating aids, ship size and fishing lanes by means of observation using a questionnaire to 10 respondents. Five respondents came from experts in the field of captured fisheries. three respondents were purse seine technicians and two were stakeholder respondents. [10] mention that expert judgment has a high level of reliability. Under certain conditions, experts are the only available

source of scientific information [11] [12]. The questionnaire table follows the rules of the AHP and is presented in Table 1.

Secondary data in this study was obtained by reviewing the literature in the form of statistical data on purse seine capture fisheries from the website https://satudata.kkp.go.id/login.aspx. Data on the number of catches available on the website are only for 2023 and 2024. The KKP does not include data before 2023 and has not updated for 2025 data.

2.2 Data analysis

2.2.1 Total and Types of Purse Seine Catches

Purse seine effectiveness can be calculated by knowing the number and types of fish caught and analyzed descriptively. The results are displayed in tabular form. The initial study carried out was to group the types of catches into 10 groups of fish. The ten groups formed refer to the Decree of the Minister of Marine Affairs and Fisheries Number 19 of 2022 concerning the estimation of potential fish resources, the number of allowable catches and the level of utilization of fish resources in the Fisheries Management Area Republic Indonesia (FMA-RI). The grouping of each type of fish is adjusted based on data accessed online via https://www.sealifebase.se/home.htm. The number and types of catches are also displayed in the form of a percentage calculated by the formula:

$$P = \frac{n_i}{N} \text{ x } 100\%$$

Where P is the proportion of a certain group of fish (%), n_i is the number of fish species to-i (tons), N is the total number of catches.

2.2.2 Purse Seine Effectiveness

The formula used in calculating purse seine effectiveness is referred to from [13] and [14], namely:

$$E_i = \frac{\sum h_i}{\sum^H}$$

Where E_i is catch effectiveness, h_i is total catch based on certain criteria, H is total catch overall.

2.2.3 Analytical Hierarchi Process (AHP)

The indicators that affect the effectiveness of the purse seine are determined and sorted using AHP analysis. This analysis is carried out through several stages [15], namely decomposition (dividing the problem into elements in the form of a hierarchical structure and each element is interconnected), comporative judgment (assessment of two elements at a certain level and affects the priority order of the elements), synthesis of priority (weighing the decision-making elements using eigenvectors), logical consistency (sequencing decision-making by obtaining a vector composite).

The decomposition process is the initial process for AHP. The output is a hierarchical structure consisting of the first level is the goal of the decision, the second level is the criteria and the third level is the alternative. The hierarchical structure of AHP is presented more clearly in **Figure 1**. After that, prioritization is carried out by creating a paired matrix as shown in **Table 2**.

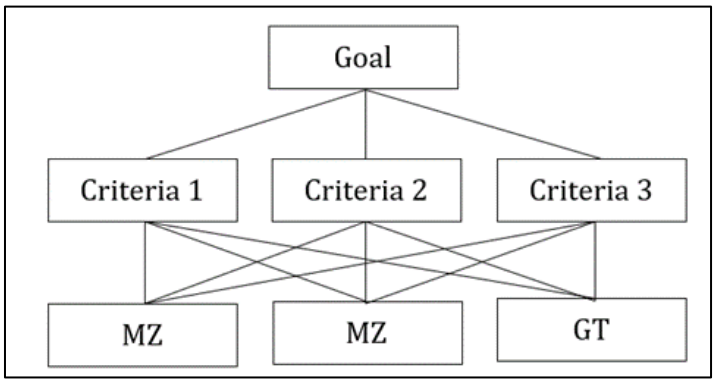


Figure 1: Hierarchical structure

Table 2: Criteria comparison matrix

C	A_1	A_2	A_3	A_n
A_1	A_{11}	A_1	A_{13}	A_{1n}
A_2	A_{21}	A_{22}	A_{23}	A_{2n}
A_3	A_{31}	A_{31}	A_{33}	A_{3n}
A_m	A_{m1}	A_{m2}	A_{m3}	A_{mn}

The matrix of each criterion value is summed and starts calculating the priority column. The priority column value is obtained from the value of the number of rows divided by the number of criteria. After that, you can calculate the consistency ratio of [16] with the formula:

$$CI = \frac{\lambda_{max} - n}{n-1}$$

Where CI is the deviation ratio, max is the largest eigenvalue of the matrix of order n, n is the order of the matrix or the number of criteria.

$$CR = \frac{CI}{IR}$$

Where *CR* is a consistent ratio and *RI* is a random index (**Table 3**). The consistency ratio is determined if the CR value 0.1, then the answers to the questionnaire from several respondents are declared consistent. If the CR value is 0.1, then the answers to the questionnaire are declared inconsistent and need to be reassessed.

Table 3: Index of Random Consistency (IR)

MS	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
IR	0.00	0.58	1.90	1.12	1.24	1.32	1.41	1.45
MS	9	10	11	12	13	14	15	
IR	1.49	1.51	1.48	1.56	1.57	1.59	1.59	

Note: MS = Matric Size

3 RESULTS AND DISCUSSION

3.1 Total and Types of Purse Seine Catches

The total and types of catches greatly affect the effectiveness of a fishing gear. The type of fish will affect the price. The price of fish affects the production value of a fishing gear. The types of catches in the study were divided into 10 groups, namely large and small pelagics. demersal, coral, shrimp, lobster, crab, crab, squid and mussel [17]. This grouping is based on morphology, fish behavior and habitat. The number of each type of catch is presented in **Table 4**.

Based on the type and weight, the catch in 2023 was more than in 2024. In 2023 caught 71 types of fish with a weight of 20,559,297,489 tons and a production value of IDR 339.803.007.390.243. The data for 2023 has decreased. In 2023, they only got 64 types of fish with a catch weight of 6,767,787,868 tons and a production value of IDR 133,771,323,499,053. This decrease reached 3 times from the previous year. The reason is that the large pelagic caught has decreased drastically. The difference reached 1,438,919,115 tons.

The types of fish caught have various variations. The total types of fish caught by purse seines were 71 species of fish caught in 2023 and 64 species in 2024. The most fish species came from the demersal fish group (41% in 2023 and 37% in 2024). The second rank is small pelagic (27% in 2023 and 31 in 2024), followed by reef fish (18% in 2023 and 20% in 2024) and large pelagic (5% in 2023 and 6% in 2024). Uniquely, the number of demersal fish species in 2023 and 2024 had more yields than other groups of fish. Whereas purse seines are known as pelagic fishing gear and are operated in the column section until they are close to the surface of the waters. The author's analysis, demersal fish caught identically have a far vertical swimming pattern. Starting reach from 0 to 100 m.

Based on the weight of the catch, the largest catch was the large pelagic fish group. Large pelagic fish consist of tuna, skipjack, marlin. Large pelagic fish in one fish can weigh up to 10-70 kg/idv. [18] and [19]. Tuna in the Pacific Ocean is caught with an average weight size of 18 to 16 kg/idv. [20].

Table 4: Type and weight of purse seine catches.

No	Fish Grouping	2023			2024		
		∑ Type	∑ Weight (tons)	Production Value (IDR)	∑ Type	∑ Weight (tons)	Production Value (IDR)
1	Large Pelagis	4	1.480.836.166	24.893.414.636.503	4	41.917.051	1.213.639.017.179
2	Small Pelagic	19	5.707.536.035	96.028.007.484.444	20	2.782.578.310	55.301.420.758.938
3	Demersal	29	8.057.186.307	132.874.261.830.574	24	2.062.795.633	39.927.092.283.310
4	Reef Fish	13	4.402.875.354	70.523.611.760.058	13	1.520.420.409	30.208.118.344.809
5	Shrimp	1	371.303.834	6.106.270.054.187	1	941.589	36.087.998.972
6	Lobster	1	886.512	20.930.407.000	0	0	0
7	Crab	1	2.250	225.000.000	1	1.860	186.000.000
8	Blue swimming crab	1	2	60.000	0	0	
9	Squid	1	538.670.669	9.356.271.757.477	1	359.133.016	7.084.779.095.845
10	Shell	1	360	14.400.000	0	0	
Total		71	20.559.297.489	339.803.007.390.243	64	6.767.787.868	133.771.323.499.053

3.2 Purse Seine Effectiveness

The effectiveness of purse seine in the results of this study is divided into two, namely the effectiveness of purse seine based on fish groups and fishing routes. Based on the fish group, the effectiveness value of purse seine in catching demersal fish was high at 38%, followed by the effectiveness value of small pelagic fish of 31%, 20% of reef fish, 7% of large pelagic fish and the rest from other fish. The graph of the effectiveness of purse seine based on fish groups is presented in **Figure 2**.

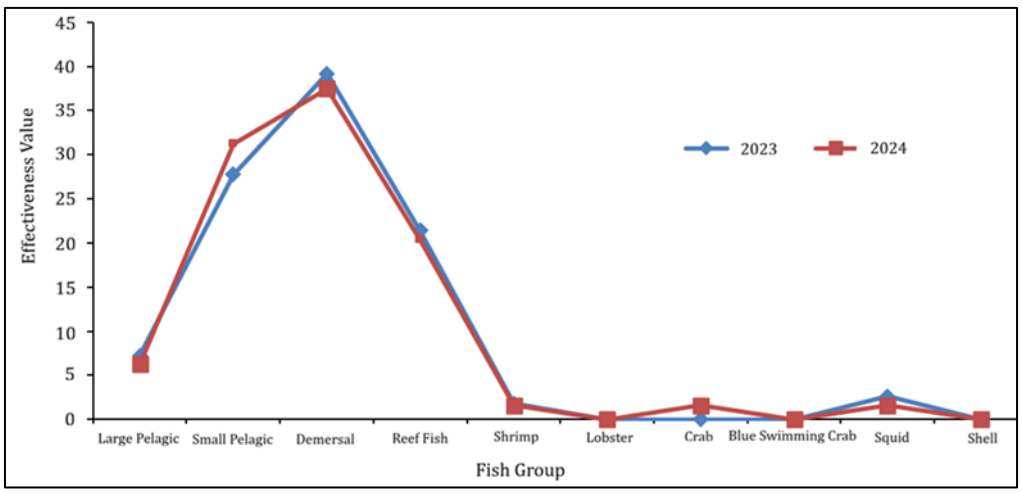


Figure 2: Purse seine effectiveness by fish group

The value of purse seine effectiveness based on the fishing area is divided into 11 Fishery Management Areas of Republic Indonesia (FMA-RI), namely FMA-RI 571, 572, 573, 711, 712, 713, 714, 715, 716, 717 and 718. The results of the calculation of purse seine effectiveness are presented in **Figure 3**, each water area has a different effectiveness value every year.

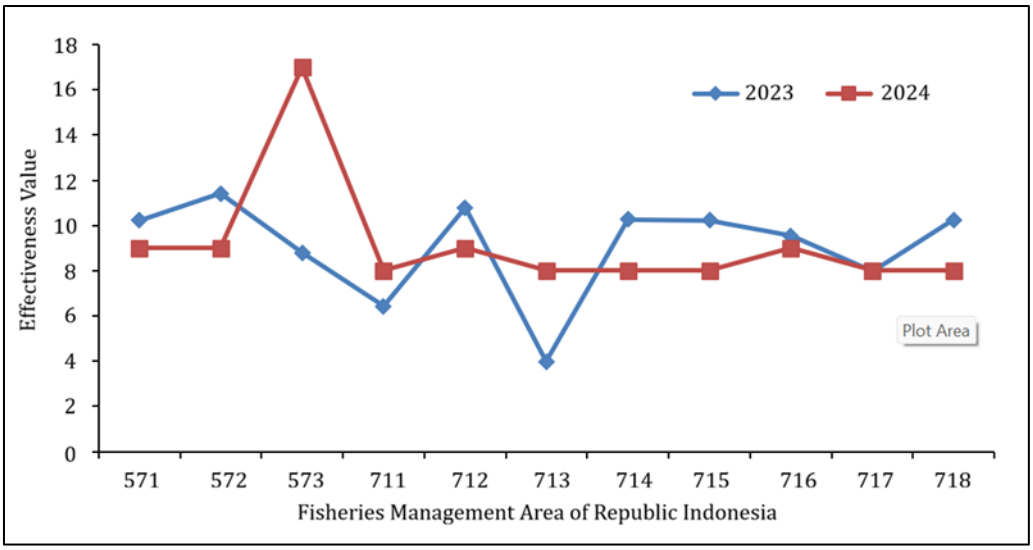


Figure 3: Purse Seine effectiveness by fishing area.

In 2019, the effectiveness of purse seine in FMA-RI 572 and 712 was the same at 11% and the lowest purse seine effectiveness in FMA-RI 713 at 4%. FMA-RI 572 covers the waters of the Indian Ocean west of Sumatra and the Sunda Strait, while FMA-RI 712 is the waters of the Java Sea. Both are strategic areas in catching large and small pelagic fish. In FMA-RI 572 it was found that the dominant types of fish caught were tuna, skipjack, mackerel and tuna with the size of the vessels used ranging from 50 to 200 GT. The largest fish landing area is in Jakarta at the Nizam Zahman Oceanic Fisheries Port (PPS), Sibolga at Nusantara Fisheries Port (PPN) Sibolga and Aceh on PPN. Sawang Ba'u. In FMA-RI 712 the most caught fish were tuna, mackerel, scad, lemuru and anchovies. The smallest purse seine effectiveness is in FMA-RI 713 (Makassar Strait, Bone Bay, Flores Sea and Bali Sea).

Purse seine effectiveness based on fishing routes in 2020 tends to be 8 to 9% evenly distributed, except in FMA-RI 573 (Indian Ocean waters south of Java to the south of Nusa Tenggara, Sawu Sea, and West Timor Sea) which have very high purse seine effectiveness reaching 17 %.

3.3 Determination of the main indicator of the effectiveness of purse seine

The determination of the main indicators of the effectiveness of purse seine operations begins with reviewing the Minister of Marine Affairs and Fisheries Regulation number 18 of 2021. The determination is divided into 4 criteria and 7 sub-criteria. The term indicator is changed to criteria. In solving AHP problems, it begins by creating an AHP hierarchical structure with predetermined goals. The flow chart is presented in Figure 4. Decision making in determining the main indicators that affect purse seine is by doing a comparison matrix analysis. The results of the comparison matrix are presented in Table 5.

Table 5: Comparison matrix for sub criteria.

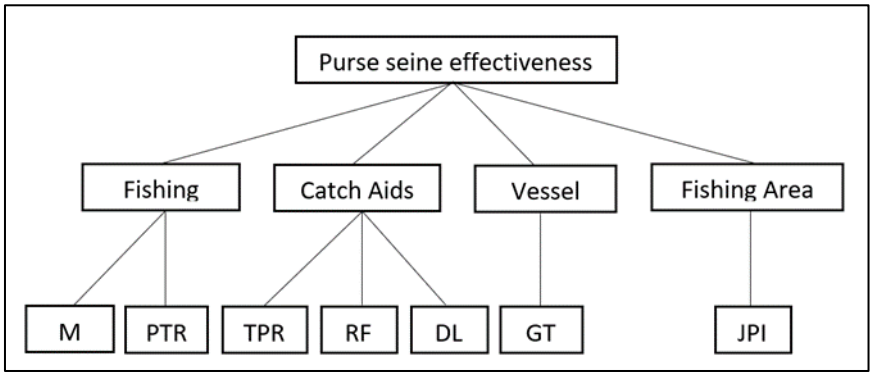
Sub Criteria	MZ	PTR	TPR	RF	DL	GT	JPI
MZ	1.00	2.00	4.00	5.00	2.00	3.00	3.00
PTR	0.50	1.00	3.00	5.00	0.50	2.00	4.00
TPR	0.25	0.33	1.00	4.00	0.33	3.00	4.00
RF	0.20	0.20	0.25	1.00	0.25	0.20	0.20
DL	0.50	2.00	3.00	4.00	1.00	3.00	3.00
GT	0.33	0.33	0.33	5.00	0.33	1.00	4.00
JPI	0.33	0.25	0.25	5.00	0.33	0.25	1.00
Total	3.11	6.12	11.83	29.00	4.74	12.45	19.20

Next is to normalize the data by dividing the value of each column by the total number of each sub-criteria and a normalized relative weight will be obtained. The eigenvector value is generated from the average value of the relative weight of each row. The calculation results can be seen in Table 6.

Table 6: Eigen vector value.

Sub Criteria	Matrix Normalization							∑ Sub Criteria	Eigen Vector
	MZ	PTR	TPR	RF	DL	GT	JPI		
MZ	0.32	0.33	0.34	0.17	0.42	0.24	0.16	1.98	0.28
PTR	0.16	0.16	0.25	0.17	0.11	0.16	0.21	1.22	0.17
TPR	0.08	0.05	0.08	0.14	0.07	0.24	0.21	0.88	0.13
RF	0.06	0.03	0.02	0.03	0.05	0.02	0.01	0.23	0.03
DL	0.16	0.33	0.25	0.14	0.21	0.24	0.16	1.49	0.21
GT	0.11	0.05	0.03	0.17	0.07	0.08	0.21	0.72	0.10
JPI	0.11	0.04	0.02	0.17	0.07	0.02	0.05	0.48	0.07

The sum of the eigenvector values of all sub-criteria is 1. This means that there is no wrong calculation in the normalization of the matrix. Next is the calculation of the maximum eigen values. The trick is to add up the result of multiplying the number of columns with the eigenvector. The result obtained is 8. The IR value is determined from the number of orders and gets a value of 1.41. The CI value gets a value of 0.17, then the AHP consistency ratio value is 0.092. Based on the assessment, the CR value is 0.092 ≤ 0.1, then the results are consistent.



Note: MZ: Mesh Size; DL: Lamp Power; PTR: Ris Rope Lenth; GT: Vessel Size; TPR: FADs and their IDs; JPI: Line Fishing; RF: Radar Reflektor

Figure 4: Hierarchical Structure Determination of Main Indicators of Purse Seine Effectiveness.

3.4 Priority Indicators of Purse Seine Effectiveness

Determination of priority indicators that are thought to affect the effectiveness of the purse seine is determined by calculating the AHP. The priority indicators that become the criteria are the mesh size of the purse seine bag, the length of the upper irs rope, FADs and their identification tags, reflector radar, lighting power, vessel size and fishing path when operating fishing gear. The results show that mesh size is a very priority indicator in determining the effectiveness of purse seines. This is evidenced by the weighting value of 3 and being in position 1. Other indicators that get the priority category are the power of the lamp and the length of the upper rope. Both have a weighting value of 2. The other three indicators are fairly priority categories, namely FADs and their identification, vessel size and fishing paths. The weighting value is 1. The indicator that gets a non-priority result with a weighting value of 0 is the radar reflector. The order and weighting of the main indicators that affect the effectiveness of purse seine are presented in Table 7 in detail.

The purse seine mesh size criteria are the first and are included in the very priority category. This criterion is the first indicator to determine the catch, especially the mesh size of the bag. Mesh size greatly affects the way fish are caught and has a function in fish operations. When the mesh size has a larger size than the fish's body size, then the fish will easily escape from the traps or obstacles of the net. When the mesh size of the net is relatively the same as the size of the fish's body circumference, the fish will be trapped in the net. When the mesh size of the net is smaller than the

circumference of the fish's body, the fish will not easily escape from the net and have a function as a barrier or herding fish into the desired part of the net.

Table 7: The order of priority indicators that affect the effectiveness of purse seine.

No	Code	Sub Criteria	Eigen Vecor	Value	Category	Rank
1	MZ	Mesh Size of Purse Seine	0.28	3	Most Priority	1
2	DL	Lamp Power	0.21	2	Priority	2
3	PTR	Ris Rope Length	0.17	2	Priority	3
4	TPR	FADs and their IDs	0.13	1	Priority Enough	4
5	GT	Vessel Size	0.10	1	Priority Enough	5
6	JPI	Line Fishing	0.07	1	Priority Enough	6
7	RF	Radar Reflektor	0.03	0	Not Priority	7

The sequence of the second and third indicators, namely the power of the lamp and the length of the upper ris line have different roles in the operation of the purse seine. The power of the lamp acts as a lure for fish to gather around FADs and fishing gear. The lights installed are the lights on the boat and the lights on the lifeboats. The master usually gives instructions to install the lamp for 30 minutes to 1 hour.

The mechanism of fish caught with the help of lights is closely related to the food chain. Lights that are installed on the surface of the waters will show and clarify the presence of plankton in the waters. Fish that have carnivorous nature will tend to approach plankton or small fish as food around the lights and eventually enter the net. The length of the top rope has a function as a framework for fishing gear nets. This tal ris is the place to hang the net. Rising ropes will also affect the length of a fishing gear and affect the shape of the mesh when operated or the hanging ratio of the net.

3.5 Implementation of Priority Indicator Ranking in Purse Seine Effectiveness

Management of fish resources must be carried out in an integrated and directed manner in accordance with applicable rules. One of them is the Code of Conduct for Responsible Fisheries (CCRF) from [21]. The implementation of CCRF in Indonesia is outlined in several government policies. One of the policies that are directly related to fishing gear is the Minister of Marine Affairs and Fisheries Regulation number 18 of 2021. The use of purse seine fishing gear has been regulated in it with the aim of managing sustainable fish resources. The level of compliance with the application of regulations is not directly monitored by the relevant parties. The port side only monitors the elements that are in accordance with the information in the letters. In fact, the information contained in the letter does not match what is happening in the field. This can be seen from the number of types of catch caught by purse seines. The effectiveness of the purse seine in catching demersal fish is higher than the effectiveness of the purse seine in catching pelagic fish. Several indications of violations occurred, namely that the purse seine was operated on a wrong path and the size of the net used was not in accordance with the regulations.

The results of the analysis of the sequence of the main indicators that affect the effectiveness of the purse seine can be applied in the government's surveillance system for purse seine fishermen. Indicators that have very priority criteria and priorities become benchmarks in eradicating illegal fishing. Other indicators become additional criteria in the monitoring carried out related to fishing gear. The application of fishing suitability based on key indicators will increase the effectiveness of a fishing gear. Increased effectiveness must also be followed by sustainable management of fish resources [22].

4 CONCLUSION

The main objective of this study is to analyze the priority indicators that determine the effectiveness of purse seine operations. So, it was concluded that the highest weight values were the criteria for the mesh size of the bag (weight 3, very priority category), lighting power and length of the top row of ropes (weight 2, priority category), FADs and their identification tags, ship size and fishing lanes (weight 1, moderate priority category) and the last order is radar reflector which has a weight of 0 with less priority criteria. The results of the study can be used as a basis for determining monitoring and evaluation policies for purse seine fisheries and maintaining the sustainability of sustainable fish resources. Further research is recommended to add alternatives in the application of this AHP analysis and design an information system for evaluating the technical suitability of purse seine operations.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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