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ASSESSMENT OF FISHING UNITS BASED ON BIOLOGICAL, TECHNICAL, AND FINANCIAL ASPECTS AT SUNGAILIAT NUSANTARA FISHERIES PORT

PENILAIAN UNIT PENANGKAPAN IKAN BERDASARKAN ASPEK BIOLOGI, TEKNIS, DAN FINANSIAL DI PELABUHAN PERIKANAN NUSANTARA SUNGAILIAT

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ABSTRACT

Sungailiat Nusantara Fisheries Port (PPN Sungailiat) is one of the fishing ports that manages fishing activities in Bangka Waters. Bangka waters have relatively high fisheries production, but the utilization of their fishery potential was not optimal, reaching only around 21.6% of the sustainable potential. This situation is suspected to be caused by the use of traditional fishing gear and inadequate fishing boats. Therefore, it is necessary to develop fishing units to optimize the utilization of the fisheries' potential. This study aims to determine priority fishing units based on biological, technical, and financial aspects. The research employed a survey of 85 fishers' respondents. Data were analyzed using a standardized scoring analysis based on the multi-criterion analysis (MCA) model. The results show that handlines and fish traps lead in biological and technical aspects attributed to their superior catch composition and operational feasibility. Furthermore, fish traps exhibit the highest financial viability with higher returns per fisher. Overall, the results of the combined analysis indicate that fish traps are the primary fishing unit to be developed in PPN Sungailiat, with a V(A) value of 2.87.

Keywords: fishing gears, multi-criterion analysis, PPN Sungailiat, sustainable fisheries

ABSTRAK

Pelabuhan Perikanan Nusantara (PPN) Sungailiat merupakan salah satu pelabuhan perikanan yang mengelola aktivitas perikanan di Perairan Bangka. Perairan Bangka memiliki produksi hasil perikanan yang cukup besar, tetapi pemanfaatan potensi perikanannya masih belum optimal, yakni baru mencapai sekitar 21,6% dari potensi lestari. Hal ini disebabkan oleh penggunaan alat tangkap masih tradisional dan kurangnya armada yang memadai. Oleh karena itu, diperlukan pengembangan unit penangkapan ikan agar pemanfaatan potensi perikanan menjadi lebih optimal dan berkelanjutan. Penelitian ini bertujuan untuk menentukan unit penangkapan ikan prioritas berdasarkan aspek biologi, teknis, dan finansial. Metode penelitian yang digunakan adalah metode survei terhadap 85 responden nelayan. Analisis data menggunakan analisis skoring yang distandardisasi dengan model *multi-criteria analysis* (MCA). Hasil penelitian menunjukkan bahwa pancing ulur dan bubu menempati urutan prioritas tertinggi dari aspek biologi dan teknis karena memiliki komposisi hasil tangkapan utama tertinggi dan kemudahan operasional. Selain itu, bubu menempati urutan prioritas tertinggi dari aspek finansial karena memiliki pendapatan per tenaga kerja yang lebih tinggi. Secara keseluruhan, hasil analisis gabungan menunjukkan bahwa bubu merupakan unit penangkapan ikan prioritas utama untuk dikembangkan di PPN Sungailiat dengan nilai V(A) = 2,87.

Kata kunci: bubu, *multi-criteria analysis*, perikanan berkelanjutan, PPN Sungailiat

INTRODUCTION

Sungailiat Nusantara Fisheries Port (PPN Sungailiat) is a type B fishing port located in Bangka Belitung Province at 106°07'20" East Longitude and 01°51'56" South Latitude. As a Technical Implementation Unit (TIU) under the Ministry of Maritime Affairs and Fisheries, PPN Sungailiat plays a strategic role in managing fishery activities in Bangka Waters and directly borders the Indonesian Fisheries Management Area (WPP-RI) 711, which is known to have abundant marine resource potential. The fishing boat operating at this port is dominated by two types of vessels, namely motorboats and outboard motorboats, with various types of fishing gear such as handlines, encircling seine nets, fixed gillnets, drift gillnets, mini purse seines, and fish traps (Tampubulon *et al.* 2022). Despite being located in an area with considerable fisheries potential, the utilization of fishery resources in PPN Sungailiat remains suboptimal. Data from the Central Statistics Agency (2020) shows that capture fisheries production in Bangka waters in 2018 was recorded at 228,980 tons/year, or only about 21.6% of the total available sustainable potential of 1,059,000 tons/year. This low utilization is due to the use of traditional fishing gear and the lack of adequate fishing boats to optimize catches (Rema 2022).

These conditions indicate the need for the development of fishing units to optimize and sustainably utilize the existing fishery potential. This development can be achieved through a comprehensive assessment of existing fishing units from a biological, technical, and financial perspective. Biological assessments are necessary to ensure that operating fishing units can maintain the sustainability of fish stocks in the sea, while technical and financial assessments are needed to assess the operational efficiency of fishing units and the feasibility of fishing efforts, providing information for fishermen to minimize the risk of loss.

This study aims to determine priority fishing units, based on biological, technical, and financial aspects, using a multi-criteria analysis (MCA) model. The results of this study are expected to provide recommendations for the Ministry of Marine Affairs and Fisheries in formulating effective policies related to the development of appropriate and sustainable fishing units to optimize the utilization of fisheries potential in Bangka Waters.

METHODS

Time and location of research

This research was conducted through three main stages. The first stage was preparation, which included the preparation of a research proposal in July–August 2023. The second stage was data collection, which took place from September to November 2023 at the Sungailiat Nusantara Fisheries Port (PPN Sungailiat). The third stage was data processing and analysis, which took place from December 2023 to January 2024. The preparation, processing, and data analysis stages were carried out at the Department of Fisheries Resource Utilization, Faculty of Fisheries and Marine Sciences, IPB University. The data collection locations are shown in Figure 1.

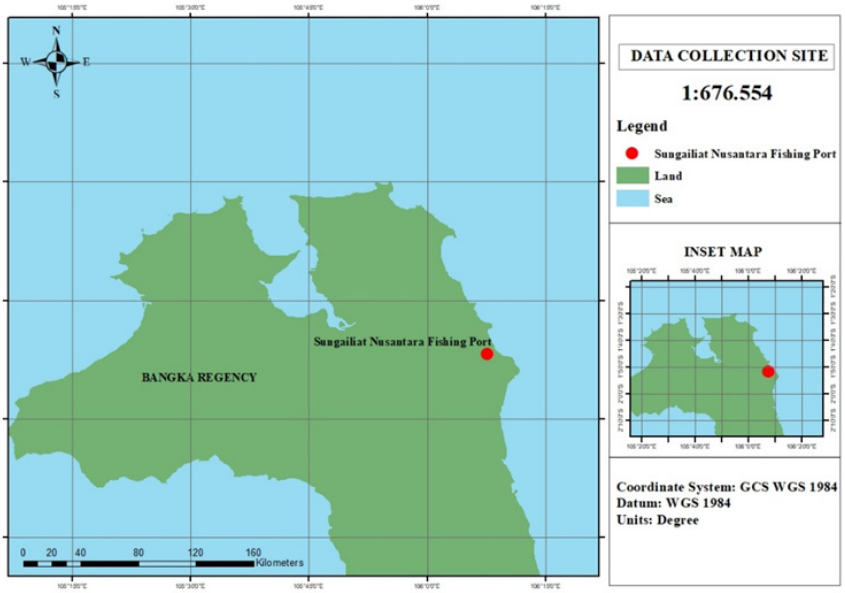

Figure 1. Data collection location at Sungailiat Nusantara Fisheries Port, Bangka.

Tools

This study utilized questionnaires and stationery as the primary instruments for collecting primary data through interviews with fishermen. The research documentation process was conducted using a mobile phone camera. The collected data was then processed and analyzed using Microsoft Excel software on a laptop.

Method of collecting data

This study employed a survey method as the primary data collection technique. In line with Darna and Herlina's (2018) definition, primary data are collected through a combination of questionnaires and in-depth interviews to gather comprehensive information from fisherman respondents. The population of fishing units in PPN Sungailiat is 794 units with fishing fleet sizes ranging from 5 to 30 GT, consisting of 463 handline units, 27 encircling seine net units, 45 fixed gillnet units, 46 drift gillnet units, 55 mini purse seine units, and 158 fish trap units. Based on this population size, a sample of 10% was taken, equivalent to 85 respondents. This sampling proportion is in accordance with Alwi's (2012) recommendation, which states that a 10% sample is representative of a population in the range of 100–1,000. Respondents were selected using a purposive sampling technique, with the criteria being fishing boat owners who also serve as captains of the handline, encircling seine net, fixed gillnet, drift gillnet, mini purse seine, and fish trap fishing units. The number of respondents consisted of 50 respondents from the handline fishing unit (5–20 GT), 3 respondents from the encircling seine net fishing unit (5–10 GT), 5 respondents from the fixed gillnet (5–10 GT), 5 respondents from the drift gillnet (5–30 GT), 6 respondents from the mini purse seine (11–30 GT), and 16 respondents from the fish traps fishing unit (5–30 GT). The variation in fishing fleet sizes does not compromise the validity of the comparison, as the analysis employs a multi-criteria analysis (MCA) model with standardized scoring. This process eliminates potential biases, ensuring that each parameter is compared objectively across different scales of operation. Respondent criteria were determined adaptively according to field conditions, prioritizing boat owners who also serve as captains. This selection was based on the consideration that these respondents have a comprehensive understanding of all operational and technical dynamics of the fishing units they manage. All respondents were fishermen who actively landed their catch at the PPN Sungailiat.

The data used in this study were the results of fishermen's information related to the biological, technical, and financial aspects of fishing units as primary data and fisheries production data at the PPN Sungailiat for 2018–2022 as secondary data, which were then collected and processed in Microsoft Excel to determine the assessment results. The biological aspect assessment focused on observing the condition of fish resource stocks to ensure sustainability and prevent overexploitation. The biological aspect criteria consisted of the length of the fish abundance season, the length of fishing trips, and the composition of the main catch. The technical aspect assessment focused on the operational efficiency of the fishing unit. The technical aspect criteria included fishing gear operation methods, operational range, and the influence of environmental conditions on fishing gear operation. The financial aspect assessment is a parameter used to determine the financial feasibility of a fishing business. The criteria focused on fisher income, which can be seen from income per year, per trip, per hour of work, per worker, and per investment costs. This income is calculated by accounting for total operational costs, including investment components, fixed costs (depreciation and maintenance of fishing units), and variable costs such as fuel, sea logistics, and fisher profit-sharing systems.

Data analysis

Priority fishing units were determined using scoring analysis. Scoring analysis is the calculation of the average value of each criterion obtained based on interview results. The results of this scoring analysis were then standardized using a multi-criteria analysis (MCA) model, expressed as follows (Mangkusubroto and Trisnandi 1987):

$$V(x) = \frac{x - x_0}{x_1 - x_0}$$

$$V(A) = \sum_{i=1}^{n} Vi(xi)$$

Description:

$V_{(x)}$ = Value function of variable x
$V_{(A)}$ = Value function of alternative A
x = Value of variable on a criterion
x_0 = Lowest value of criterion x
x_1 = Highest value of criterion x
$Vi_{(xi)}$ = Value function of alternative on criterion-i
xi = Value of alternative on criterion-i

n = Number of criteria

Multi-criteria analysis (MCA) is applied as a decision-making instrument when faced with various complex and interrelated criteria. This method serves to formulate a priority order from various alternatives to systematically determine the optimal choice. In its implementation, interview data is transformed into standardized scores. This standardization process is crucial to ensure the objectivity of the assessment by aligning the data scale so that the determination of priority fishing units can be carried out accurately. Standardization was carried out on each criterion and aspect by calculating the ratio of the difference between the observed value and the minimum value to the maximum and minimum values for that criterion and aspect. The value of V(x) is a function of the variable value of the criteria in an aspect and produces a value of V(A), which is a function of the value for an aspect (biological, technical, and financial aspects), denoted by a value of 0–1. In detail, standardization can be formulated with the following equation (Yusfiandayani *et al.* 2025):

$$Aspect(criteria) = \frac{Criteria\ value - Lowest\ criteria\ value}{Highest\ criteria\ value - Lowest\ criteria\ value}$$

Biological aspect analysis

Biological analysis was applied to estimate the impact of fishing activities in PPN Sungailiat on fish stock stability. The analysis focused on three main criteria: the length of the peak season, the duration of fishing trips expressed in months (1–12 months), and the proportion of the main catch (HTU). In this context, HTU is defined as a target species with high economic value that is consistently caught annually. Referring to Samba *et al.* (2021), a high percentage of the main catch to bycatch indicates better fishing gear selectivity and can minimize the risk of aquatic ecosystem degradation. The integration of these three main criteria indirectly reflects the dynamics of stock availability and the sustainability of fish resources in a given water body over a specific period. The score intervals for the percentage of the main catch are shown in Table 1.

Technical aspect analysis

The technical aspect examines the operational dimensions of fishing gear to evaluate the efficiency and feasibility of a fishing unit in a given water area. The evaluation was conducted through a weighted scoring system for operational methods to ensure the accuracy of fishing procedures for optimal catches. Furthermore, the operational range is measured in nautical miles to map the fishing boat's cruising radius to potential fishing zones. This analysis also integrates external variables such as the influence of environmental conditions on fishing gear operation, which are converted into specific value intervals to mitigate safety risks and technical failures. All primary data for these three criteria were collected through in-depth interviews with fishermen, covering operational ease, travel distance, and the impact of environmental conditions on fishing activities. Details of the value intervals for the operational method criteria and the influence of environmental conditions on fishing gear operation are shown in Tables 2 and 3.

Financial aspect analysis

Financial analysis is a systematic evaluation procedure to assess the economic feasibility and operational sustainability of a fishing unit. This approach aims to measure and validate whether a fishing unit is able to generate income commensurate with the capital invested (Arumtyas *et al.* 2023). This aspect can serve as a strategic decision-making instrument to determine the resilience of fishing efforts to market price fluctuations and uncertain cost changes. The data required for this approach consist of investment costs, fixed costs, variable costs, revenue, and profits. This data was obtained from interviews with fishing boat owners who also serve as captains of fishing units using handlines, encircling seine nets, fixed gillnets, drift gillnets, mini purse seines, and fish traps, with a total of 85 respondents. Furthermore, fisheries production data at the PPN Sungailiat for 2018–2022 were used as supporting data. In this study, the financial aspect focused on the criteria of annual income, per trip, per hour worked, per worker, and per investment cost.

Combined aspect analysis

A combined aspect approach was conducted by standardizing each parameter across biological, technical, and financial dimensions into equivalent values. These values were processed through a multi-criteria analysis (MCA) model to determine priority fishing units. All data were scaled from 0 to 1 to ensure that criteria with different measurement units could be compared proportionally (Yusfiandayani *et al.* 2025).

Table 1. Main catch percentage (MCP) score intervals for gear selectivity assessment.

Value Intervals	Indicators	Description
1–2	MCP = 10%–30%	Not selective
3–4	MCP = 30%–50%	Less selective
5–6	MCP = 50%–70%	Moderately selective
7–8	MCP = 70%–90%	Selective
9–10	MCP = 90%–100%	Very selective

Source: Samba *et al.* (2021)

Table 2. Interval scores for fishing gear operating methods.

Value Intervals	Categories	Descriptions
1–2	Difficult	The fishing gear used can result in death for fishermen, making it difficult for them to operate their fishing gear.
3–4	Quite difficult	The fishing gear used can cause temporary health problems, but they can still operate the fishing gear.
5–6	Easy	The fishing gear used is safe for fishermen, ensuring they are skilled and capable of operating the fishing gear.

Source: Imron *et al.* (2021)

Table 3. Interval scores for the influence of environmental conditions on the operation of fishing gear.

Value Intervals	Categories	Descriptions
1–2	Influential	Currents and waves are obstacles
3–4	Moderately influential	Currents and waves are obstacles, but fishermen can still overcome them.
5–6	Not influential	Currents and waves are not obstacles.

Source: Imron *et al.* (2021)

RESULTS AND DISCUSSION

General Conditions of the Sungailiat Nusantara Fisheries Port

The landed catch at Sungailiat Nusantara Fisheries Port (PPN Sungailiat) during 2018–2022 showed an unstable pattern between fishing gear. However, Nurhayati (2013) noted that the intensity of continuous fishing efforts generally caused a decline in fish stocks in their natural habitat. This phenomenon has been identified as one of the main triggers for fluctuations in fisheries production figures. In addition to the availability of fish resources, Mayu *et al.* (2018) emphasized that operational fishing efficiency, oceanographic conditions such as currents and waves, and the financial stability of fishermen determine the uncertainty of the amount of catch landed by fishermen. Details of fluctuations in fisheries production volume from 2018–2022 are shown in Table 4.

Based on these data, the highest fisheries production volume in PPN Sungailiat is dominated by the mini purse seine fishing unit. This high production figure is due to its characteristics as an active fishing gear operated by encircling schools of fish (Guntur *et al.* 2013). Operationally, the mini purse seine's capability is capable of landing catches of up to two tons in a single fishing trip. Conversely, the lowest production figures were recorded in the fixed gillnet fishing unit. This low production figure is the impact of the limited abundance period of the target fish species compared to other fishing units. Monthly catch production in 2022 is presented in the graph in Figure 2.

Assessment of biological aspects

The assessment criteria for fishing units based on biological aspects consist of three criteria: the length of the fish abundance season (months) (X1), the length of fishing gear operation (months) (X2), and the composition of the main catch (X3). The values listed in criteria X1 and X2 are obtained from the sum of the length of the fish abundance season and the duration of the fishing trip expressed in months (1–12). The value listed in criterion X3 is obtained from the value interval results in the form of a score according to the assessment

details presented in Table 1, and is a percentage of the composition of the main catch.

The assessment of this aspect is carried out to see whether the type of fishing gear used can damage other marine biological resources or not (Wulandari *et al.* 2017). This assessment can also help in identifying the condition of fish resource stock abundance in a body of water. The following are the results of the analysis of the biological aspect assessment contained in Table 5.

Table 4. Fishery production volume based on fishing gear type in Sungailiat Nusantara Fisheries Port 2018–2022.

Year	Production Volume (kg)					
	Handline	Encircling Seine Net	Fixed Gillnet	Drift Gillnet	Mini Purse Seine	Fish Traps
2018	799,518	688,675	288,856	458,982	2,136,517	563,784
2019	793,958	270,956	177,650	281,789	3,034,097	611,902
2020	453,828	263,394	175,354	209,748	3,588,642	624,870
2021	576,587	216,517	175,392	252,214	3,277,527	646,892
2022	507,061	283,530	238,855	201,645	2,209,404	616,519

Source: Operational data of Sungailiat Nusantara Fisheries Port (2022)

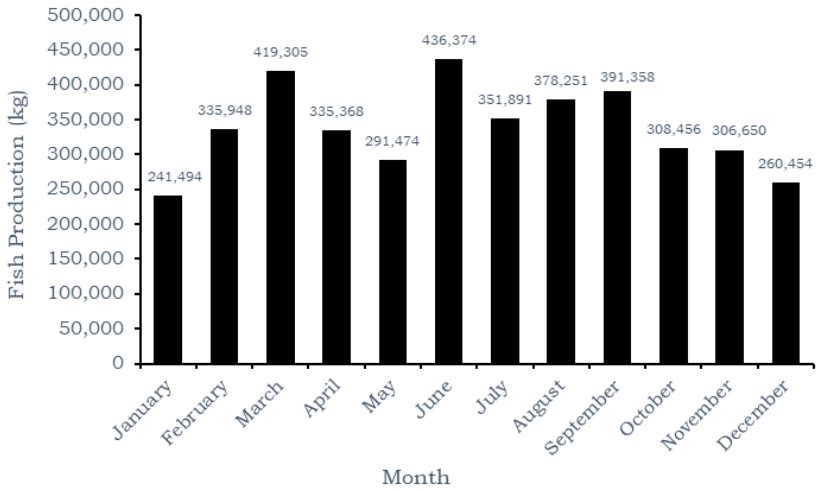

Figure 2. Monthly fisheries production at Sungailiat Nusantara Fisheries Port in 2022 (kg). Source: Operational data of Sungailiat Nusantara Fisheries Port (2022).

Table 5. Assessment of biological aspect criteria in various fishing units.

Fishing Unit	Criteria					
	X1	UP1	X2	UP2	X3	UP3
Handline	7	1	12	1	9	1
Encircling Seine Net	4	4	12	1	8	2
Fixed Gillnet	5	3	12	1	6	4
Drift Gillnet	6	2	12	1	7	3
Mini Purse Seine	4	4	12	1	4	5
Fish Traps	7	1	12	1	9	1

Description:
X1 = Length of fish abundance in season (months)
X2 = Fishing trip duration (months)
X3 = Composition of main catch (score)
UP = Priority

The handline fishing unit has a total fishing season of 7 months, with the main catch types being squid, mackerel, threadfin bream, bigeye scad, yellowtail scad, veined catfish, grouper, and mackerel, which have a fishing season in January, February, March, April, May, June, July, and October. The encircling seine net fishing gear has a total fishing season of 4 months, with the main catch types being black pomfret and yellowstripe scad, with a fishing season pattern in March, June, July, and August. Fixed gillnet has a total fishing season of 5 months, with the main catch types being ribbon tap stingrays and giant shovelnose rays. Drift gillnet has a total fishing season of 6 months, with the main catch types being white tuna, Indian mackerel, and Narrow-barred Spanish mackerel. Mini purse seine produces the highest production volume in PPN Sungailiat and has the same total fishing season as encircling seine net, which is 4 months, namely in March, June, July, and August, with the main catch being bigeye scad, yellowtail scad, and Indian mackerel. Fish trap has the same total fishing season as handline fishing, which is 7 months, namely in September, October, November, December, January, February, and March, with the main catch being triggerfish, red snapper, leopard coral grouper, emperor, yellowtail, and mala. The results of interviews with fishermen in PPN Sungailiat showed that all fishing gear in PPN Sungailiat always operates throughout the year, which is 12 months, including during the west season (the lean season), although the frequency of fishing gear operating in PPN Sungailiat has decreased. Based on the analysis, the fishing gear that catches the main catch is handline fishing gear and fish trap, with a percentage of 93%, so that it occupies the first priority order. The priority order is determined to identify the most effective fishing gear based on each criterion. Next, the results of the biological aspect assessment in the fishing unit were standardized, and the results of this standardization are presented in Table 6.

The assessment of the biological aspects of fishing units after standardization using the value function places handlines and fish traps as the first priority. This is because both fishing gears have the same total fishing season, namely 7 months, and a higher percentage of the main catch composition compared to other fishing gears. Hehanussa (2017) explains that fish traps are capable of catching more main catch than bycatch. The fishing gear that ranks last in priority is the mini purse seine. This is due to the low ability of this fishing gear to catch the main catch.

Technical aspect assessment

The assessment criteria based on technical aspects consist of three criteria: the fishing gear operating method (X1), the operational range (X2), and the influence of environmental conditions on the operation of the fishing unit (X3) (Wiyono 2011). The X1 and X3 values are obtained from the score interval parameters as shown in Tables 2 and 3. The X2 value is obtained from the results of interviews with fishermen regarding the operational range of the fishing unit, expressed in nautical miles. This technical aspect assessment aims to determine the efficiency and operational feasibility of the fishing unit in a given water location. The efficiency of fishing operations is influenced by the operating method and the influence of environmental conditions on the operating method of the fishing unit. An effective fishing unit can operate easily and achieve the desired catch without high risk. The results of the technical aspect analysis of the fishing unit can be seen in Table 7.

Table 6. Results of the assessment of biological aspects of fishing units after standardization.

Fishing Unit	Criteria			Number	Priority
	V(X1)	V(X2)	V(X3)		
Handline	1,00	1,00	1,00	3,00	1
Encircling Seine Net	0,00	1,00	0,80	1,80	3
Fixed Gillnet	0,33	1,00	0,40	1,73	4
Drift Gillnet	0,67	1,00	0,60	2,27	2
Mini Purse Seine	0,00	1,00	0,00	1,00	5
Fish Traps	1,00	1,00	1,00	3,00	1

Description:

V(X1) = Standardization value of the length of the fish abundance season

V(X2) = Standardization value of fishing trip duration

V(X3) = Standardization value of main catch composition

Table 7. Assessment of technical aspect criteria in various fishing units.

Fishing Unit	Criteria					
	X1	UP1	X2	UP2	X3	UP3
Handline	6	1	90	3	4	1
Encircling Seine Net	4	3	120	2	2	3
Fixed Gillnet	5	2	55	5	3	2
Drift Gillnet	5	2	60	4	3	2
Mini Purse Seine	3	4	150	1	2	3
Fish Traps	6	1	120	2	3	2

Description:
X1 = Method of operating fishing gear (score)
X2 = Operational range (nautical miles)
X3 = The influence of environmental conditions on the operation of fishing units (score)
UP = Priority

The operating method of the handline and fish traps received a score of 6, meaning its operation is easy, and the mini purse seine received a score of 2, meaning its operation is difficult because it requires the skill of the ship's captain in encircling the fish with the right speed and time to lower the net. The operation of the handline and fish traps only requires 1–6 crew members (ABK), while the operation of the mini purse seine fishing gear requires 9–15 crew members. The longest range is owned by the mini purse seine, which is 150 miles, while the shortest range is owned by the fixed gillnet, which is 55 miles. The long operating range indicates how much and how far the fishing area of the fishing gear can affect the amount of catch they get. The fishing units that have the most influence on environmental conditions are the mini purse seine and encircling seine net fishing gear. This is because the mini purse seine and encircling seine net use quite large fishing boats, so that waves and currents greatly affect the speed of the vessel in operation. Furthermore, the primary target of mini purse seine and encircling seine net fishing gear is pelagic fish, which are difficult to catch in strong waves and currents (Nanlohy 2011). The results of the technical assessment were then standardized, and the results of this standardization are presented in Table 8.

The assessment of the technical aspects of fishing units after standardization with a value function places handline fishing gear as the first priority. This is because handline fishing gear has an easier operation method, and environmental conditions are less influential when compared to other fishing gear. Baroqi *et al.* (2023) explained that handline fishing gear is an efficient fishing gear because it has an easy operation method, does not require a lot of labor, and can be operated at certain water depths. The fishing gear that ranks last in priority is the mini purse seine. This is due to the relatively difficult operational method and the environmental conditions that affect the operation of this fishing gear.

Table 8. Results of the technical aspect assessment of fishing units after standardization.

Fishing Unit	Criteria			Number	Priority
	V(X1)	V(X2)	V(X3)		
Handline	1.00	0.37	1.00	2.37	1
Encircling Seine Net	0.33	0.68	0.00	1.02	5
Fixed Gillnet	0.67	0.00	0.50	1.17	4
Drift Gillnet	0.67	0.05	0.50	1.22	3
Mini Purse Seine	0.00	1.00	0.00	1.00	6
Fish Traps	1.00	0.68	0.50	2.18	2

Description:
V(X1) = Standardization value of fishing gear operating methods
V(X2) = Operational range standardization value
V(X3) = Standardization value of the influence of environmental conditions on the operation of fishing units

Financial aspect assessment

Financial assessment is an economic evaluation process aimed at measuring the profitability and sustainability of investments in each fishing unit. Indradi *et al.* (2013) stated that although the capture fisheries sector has high operational risks, this sector remains a promising business opportunity that can generate significant profits if managed properly. This analysis is important because it serves as a basis for fisheries business actors in conducting accurate financial planning and determining strategies to minimize potential financial losses. The financial assessment in this study uses five main criteria that provide an overview of business efficiency, from operational scale to the productivity of invested capital.

The fundamental difference between these five criteria lies in the unit of analysis and its purpose in analyzing a business's financial condition. Annual revenue (X1) is used to monitor the long-term financial stability of the business, while revenue per trip (X2) focuses on the efficiency of the results obtained each time the fishing boat makes a fishing trip. Revenue per hour worked (X3) is analyzed to assess the productivity of time spent during fishing operations, while revenue per worker (X4) is an important indicator of the distribution of welfare among fishermen or crew members. Revenue per investment cost (X5) measures the amount of revenue generated relative to the initial capital outlay for procuring fishing equipment. All of these criteria can provide a comprehensive conclusion regarding the most financially promising fishing units, the results of which can be seen in Table 9.

Based on the assessment of each financial criterion, the first priority in the annual income criteria is the mini purse seine fishing gear, and the last priority is the fixed gillnet. Income is influenced by the type and selling value of the catch (Imron *et al.* 2024). The first priority in the income per trip criterion is the fish trap fishing gear. This is influenced by the number of days on one fishing trip. A fish trap has 24 trips in 1 year, equivalent to 2 trips in 1 month. One fishing trip lasts 15 days, and the last priority is the encircling seine net. The first priority in the income per hour criterion is the mini purse seine fishing gear, and the last priority is the handline fishing gear. This is influenced by the number of working hours of the handline fishing gear, which is 56 hours in one fishing trip. The first priority in the income per worker criterion is the fishing trap, and the last priority is the encircling seine net. This is influenced by the amount of income divided by the number of workers required; the more workers, the less income earned per worker. The first priority in the income-per-investment-cost criteria is the mini purse seine fishing gear, and the last priority is the fixed gillnet. The results of the financial assessment of the fishing unit after standardization can be seen in Table 10.

Table 9. Assessment of financial aspect criteria in various fishing units.

Fishing Unit	Criteria									
	X1	UP1	X2	UP2	X3	UP3	X4	UP4	X5	UP5
Handline	648	4	13.5	4	241.07	6	10.22	2	4.32	3
Encircling Seine Net	720	3	10.0	5	250	5	1.01	6	4.16	4
Fixed Gillnet	540	5	15.0	3	375	3	1.92	5	3.38	6
Drift Gillnet	648	4	13.5	4	321	4	2.25	4	4.02	5
Mini Purse Seine	1,440	1	20.0	2	1.00	1	8.00	3	5.43	1
Fish Traps	960	2	40.0	1	666.67	2	20.00	1	5.13	2

Description:

X1 = Annual income (Rp) in million IDR

X2 = Income per trip (Rp) in million IDR

X3 = Operating hourly revenue (IDR)

X4 = Income per worker (IDR/month)

X5 = Income per investment cost (IDR)

UP = Priority

Table 10. Results of the assessment of the financial aspects of fishing units after standardization.

Fishing Unit	Criteria					Number	Priority
	V(X1)	V(X2)	V(X3)	V(X4)	V(X5)		
Handline	0.12	0.12	0.00	0.48	0.46	1.18	3
Encircling Seine Net	0.20	0.00	0.01	0.00	0.38	0.59	5
Fixed Gillnet	0.00	0.17	0.18	0.05	0.00	0.39	6
Drift Gillnet	0.12	0.12	0.11	0.07	0.32	0.72	4
Mini Purse Seine	1.00	0.33	1.00	0.37	1.00	3.70	2
Fish Traps	0.47	1.00	0.56	1.00	0.85	3.88	1

Description:
V(X1) = Standardized value of income per year
V(X2) = Standardized value of income per trip
V(X3) = Standardized value of revenue per hour of operation
V(X4) = Standardized value of income per worker
V(X5) = Standardized value of income per investment cost

The overall financial assessment results indicate that fishing trap fishing gear is the most popular because it makes more fishing trips than other fishing gear. Therefore, the fish trap has a higher income per worker. Income can also increase if the production equipment used in a fishery is used efficiently, and the workforce also contributes to increased fishing production. The second priority is the mini purse seine, and the third is the handline.

Combined aspect assessment

The combined aspect is carried out by making the existing values from the assessment results of each aspect into a new criterion assessment that can be analyzed (Yusfiandayani *et al.* 2025). The previously analyzed aspects, namely biological (X1), technical (X2), and financial (X3), are combined into one final analysis to obtain the value of the priority fishing unit at the PPN Sungailiat, which is shown in Table 11. The assessment of this aspect is also the final stage in this study, and the results can be used as a reference for the Ministry of Maritime Affairs and Fisheries in formulating policies for the development of appropriate and sustainable fishing units.

The handline fishing unit is prioritized for biological and technical aspects, while the fish trap is prioritized for financial aspects. Table 11 represents the combined analysis of all assessed aspects, which were then standardized using the multi-criterion analysis (MCA) method. This analysis was conducted by standardizing each criterion across three aspects: biological, technical, and financial. The results of the combined aspect standardization assessment can be seen in Table 12.

Based on the combined analysis standardization results table, it was found that the fish trap was ranked first and the encircling seine net was ranked last. From a biological perspective, handlines excel in the criterion of fishing season length and main catch composition. Handlines have a longer fishing season and a higher percentage of main catch composition expressed in score intervals compared to other fishing gear. From a technical perspective, handlines are ranked first, and mini purse seines are ranked last. This is because handlines have a relatively easy operating method because they do not require a lot of labor or difficult equipment to operate, and are not affected by environmental conditions.

From a financial perspective, fish traps are the top priority. This is because the fish trap generates higher revenue per trip and income per worker than other fishing gear, thus influencing the scoring for the economic analysis of fish trap fishing gear. Based on the combined analysis, sustainable fishing units can be developed in the first priority order, namely fish trap fishing gear with a V(A) value of 2.87, the second priority order is handline fishing gear with a V(A) value of 2.23, and the last priority order is encircling seine net fishing gear with a V(A) value of 0.47. The most appropriate fishing gear or priority developed by PPN Sungailiat, based on biological, technical, and financial aspects, is the fish trap. The Ministry of Marine Affairs and Fisheries can formulate fisheries management policies in development efforts, so that the potential of capture fisheries at PPN Sungailiat can be optimally utilized.

Table 11. Assessment of combined aspects (biological, technical, and financial aspects) in fishing units.

Fishing Unit	Criteria					
	X1	UP1	X2	UP2	X3	UP3
Handline	3.00	1	2.37	1	1.18	3
Encircling Seine Net	1.80	4	1.02	5	0.59	5
Fixed Gillnet	1.70	5	1.17	4	0.39	6
Drift Gillnet	2.30	3	1.25	3	0.72	4
Mini Purse Seine	1.00	6	1.00	5	3.70	2
Fish Traps	3.00	2	2.18	2	3.88	1

Description:
X1 = Biological aspects
X2 = Technical aspects
X3 = Financial aspects
UP = Priority

Table 12. Results of the combined aspect assessment of fishing units after standardization.

Fishing Unit	Criteria			Number	Priority
	V(X1)	V(X2)	V(X3)		
Handline	1.00	1.00	0.23	2.23	2
Encircling Seine Net	0.40	0.01	0.06	0.47	6
Fixed Gillnet	0.37	0.12	0.00	0.49	5
Drift Gillnet	0.64	0.16	0.10	0.89	3
Mini Purse Seine	0.00	0.00	0.95	0.95	4
Fish Traps	1.00	0.87	1.00	2.87	1

Description:
V(X1) = Standardization value of biological aspects
V(X2) = The value of the standardization of technical aspects
V(X3) = Standardization value of financial aspects

CONCLUSION

This study shows that the fish trap fishing unit has the highest overall value (V(A) = 2.87) and is therefore the top priority for sustainable development in PPN Sungailiat. Handlines also demonstrate strong performance, particularly in biological and technical aspects. The development of fish trap fishing units is considered an effective strategy to optimize and sustain the utilization of the fisheries' potential. However, this study is limited to biological, technical, and financial aspects. Future research should incorporate environmental, social, and policy dimensions to provide a more comprehensive evaluation of sustainable fisheries development.

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