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# Bioeconomics of shortfin scad (*Decapterus macrosoma*) landings at Nusantara Fishing Port (PPN) Tasikagung, Indonesia

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## Abstract

Pelagic fish resources are one of the most important potential resources in Indonesian waters. One small pelagic fish that has high economic value and is currently in high demand is the shortfin scad (*Decapterus macrosoma*). The production of *D. macrosoma* in the Nusantara Fishing Port (PPN) Tasikagung is very large. This has led to increased fishing efforts without regard to the existence and sustainability or conservation of the species. This study specifically discusses the bioeconomic analysis of the fishing of *D. macrosoma.* Therefore, this study aims to make a significant contribution to the development of *D. macrosoma* fishing in the PPN Tasikagung and surrounding areas. The bioeconomic study of *D. macrosoma* fishing uses the Gordon Schaefer model, which includes Maximum Sustainable Yield (MSY), Maximum Economic Yield (MEY), Open Access Equilibrium (OAE), utilisation rate and exploitation rate. Several aspects to be assessed in this study include technical aspects of fishing, bioeconomic aspects of fisheries, and utilisation rates. Data collection was carried out through observation, interviews, documentation, and literature studies. The results of the study obtained an average CPUE value for the 2020–2024 period of 29.193 kg per unit. Under MSY conditions, a $C_{MSY}$ value of 15,283,570 kg was obtained, an $E_{MSY}$ value of 601 fishing gear units per year with a profit of IDR 56,181,648,063. Under MEY conditions, the $C_{MEY}$ value was 15,283,338 kg, the $E_{MEY}$ was 599 fishing gear per year, with a total profit of 56,182,508,405. Fishing efforts under OAE conditions yielded a $C_{OAE}$ value of 237,371 kg per year and an $E_{OAE}$ of 1,198 fishing gear units per year. The level of exploitation of *D. macrosoma* resources has reached moderate exploitation with an exploitation rate of 95% and an effort rate of 85%, and the level of exploitation produces an effort of 1.19, which means $0.5 \le E < 1$= Fully exploited. Fishing efforts are closely monitored to ensure that the *D. macrosoma* resources at the PPN Tasikagung are not overfished, thereby supporting the sustainability of *D. macrosoma* fishing efforts in the future and improving the welfare of the fishermen themselves.

**Keywords:** *Decapterus macrosoma*; Maximum Sustainable Yield (MSY); Maximum Economic Yield (MEY); Open Access Equilibrium (OAE)

## 1. Introduction

Fisheries are an important sector of the Indonesian economy, particularly in coastal areas. One commodity with high economic value is the shortfin scad (*Decapterus macrosoma*) [1]. *D. macrosoma* is a small pelagic commodity that is very important in the Java Sea, particularly around Bawean and Karimunjawa Islands, due to its abundance and high economic value. The *D. macrosoma* fishing season in the Java Sea generally occurs from July to November, with abundant catches and fluctuations in Catch Per Unit Effort (CPUE) influenced by fishing intensity and marine environmental conditions [2].

The fishing fleet at PPN Tasikagung is dominated by 10–30 GT Mini Purse Seine and mini trawl as the main fishing gear

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[3][4]. This fleet plays an important role in supporting the production of *D. macrosoma* landed at PPN Tasikagung, with an operating area covering the Java Sea, especially around the islands of Bawean and Karimunjawa [5].

The fishing grounds in FMA-RI 712, particularly around Bawean and Karimunjawa Islands, are known as highly productive small pelagic fishing zones, supported by oceanographic conditions such as sea surface temperatures of 26–29°C and chlorophyll-a concentrations of 0.5–2.5 mg/m$^3$ [6]. This zone is also influenced by the seasons, where during the east monsoon, the fishing area is concentrated in the eastern part of the Java Sea, while during the west monsoon it is spread out in the western part.

The bioeconomic aspects of *D. macrosoma* fishing include an analysis of the costs and benefits associated with fishing activities and their impact on fish populations [7]. Previous studies have shown that poorly managed fishing can lead to population decline and negative impacts on marine ecosystems [8]. Therefore, it is important to develop a bioeconomic model that can assist fishermen and fisheries managers in making sustainable decisions.

This study aims to provide data-based recommendations for sustainable *D. macrosoma* management in PPN Tasikagung. By considering bioeconomic aspects, it is hoped that the results of this study can be used as a basis for better fisheries policies and support the sustainability of fishery resources in Indonesia.

## 2. Material and methods

This research was conducted from January to May 2025 at the PPN Tasikagung located in Rembang, Central Java. The tools and materials used in this research included boats, purse seines, measuring tapes, cameras, writing instruments, and laptops.

### 2.1. Sampling and Data Collection Methods

The primary and secondary data collection methods in this study used four (4) methods, namely:

1. Observation, which involved direct observation by participating in fishing operations and making detailed notes on the study or issue being researched or observed.
2. Interviews, which are question and answer sessions conducted by an interviewer as the questioner and a resource person as the person being questioned. This activity is carried out to seek information, request explanations, or ask opinions about a problem from someone [9]. These interviews cover data on vessels and fishing gear, fishing operations, production, operations management, and others.
3. Documentation was carried out during interviews with fishermen who catch *D. macrosoma*. The documentation method was used as supporting evidence for the research.
4. Literature study, namely a description of theories, findings, information and other research materials obtained from reference materials to be used as a basis for research activities such as Maximum Sustainable Yield (MSY), Maximum Economic Yield (MEY), Open Access Equilibrium (OAE) and secondary information and data to support the research.

### 2.2. Data Analysis Methods

The technical aspect analysis in this study aims to assess the efficiency of *D. macrosoma* fishing activities carried out by fishermen at the PPN Tasikagung. The technical aspect is analysed by assessing the relationship between fishing effort and catch yield obtained by fishermen [11]. Fishing effort is measured based on the number of fishing trips, the number of vessels in operation, the duration of fishing, and the type and number of fishing gear used. Meanwhile, catch is assessed based on the volume of *D. macrosoma* landed per unit of time or per fishing trip [12].

#### *2.2.1. Catch Per Unit Effort (CPUE) Analysis*

CPUE is calculated with the aim of determining the level of abundance and utilization of fishery resources in a water area. CPUE calculations are carried out by collecting production data (Catch) and fishing trips (Effort) in a certain year according to the type of Fishing Gear used [13].

#### *2.2.2. Maximum Sustainable Production Analysis (MSY)*

Maximum Sustainable Yield (MSY) is a theoretical concept that is widely used in fisheries science and management. MSY fisheries are defined as the optimum catch (in quantity or mass) that can be taken from a population in an unlimited period [14].

*2.2.3. Maximum Economic Yield Analysis (MEY)*

MEY is the optimum catch that can be obtained continuously (on sustained basis). If the actual catch is less or less than MSY due to insufficient fishing effort, then biologically the fishery is said to be underfishing and further development is possible [15].

*2.2.4. MSY, MEY Formula Using the Gordon-Schaefer Analysis Model*

The Gordon-Schaefer bioeconomic study model is a fisheries monitoring method that can obtain ideal monetary benefits by focusing on the relationship between fishing effort and utilization which must be viewed from a natural and financial perspective by utilizing the following conditions [16].

**Table 1** MSY, MEY Formula Using the Gordon-Schaefer Analysis Model

| Description | MSY | MEY | OAE |
|---|---|---|---|
| Catch (C) | α / 4β | αEMEY – β(EMEY)2 | αEOAE – β(EOAE)2 |
| Fishing effort (E) | α / 2β | (pα – c) / (2pβ) | (pα – c) / (pβ) |
| Total revenue (TR) | CMSY. P | CMEY. P | COAE. P |
| Total expenditure (TC) | c. EMSY | c. EMEY | c. EOAE |
| Profit (π) | TRMSY - TCMSY | TRMEY - TCMEY | TROAE – TCOAE |

Description:

- α : intercept (Schaefer model)
- β : slope (Schaefer model)
- p : price
- c : cost
- MSY : Maximum Sustainable Yield
- EMSY : Sustainable Fishing Effort

*2.2.5. Open access equilibrium (OAE)*

In an open access equilibrium condition in fishing, the amount of costs incurred will be equal to the amount of total revenue, so that the amount of profit is 0 [17]. [18] states that the level of effort required in open access conditions is much greater than in MEY and MSY conditions, and the catch is much smaller than in MSY and MEY conditions. This condition is characterised by high input and low fish biomass. Fish stocks will be exploited to the lowest point because fish resources have open access properties. At the MEY level, the input required is not too much, but biomass equilibrium is achieved at a higher level [19].

*2.2.6. Analysis of Utilisation and Exploitation Levels*

The effort level is the final analysis of the MSY, MEY, and OAE calculations. By calculating the $E_{msy}$ effort level after determining the $C_{msy}$ utilisation level [20]. The fishing gear effort level is obtained after determining the optimum effort level.

$$TPc = \left(\frac{Ci}{Cmsy}\right) \text{ x } 100\%$$

Explanation:

TPc = utilisation rate (%)

Ci = catch in year i (kg)

$C_{msy}$ = sustainable catch (kg)

After determining the utilisation rate, it is also necessary to determine the effort rate. The effort rate of fishing gear is obtained after determining the optimum effort rate [21].

$$TPe = (\frac{Ei}{Emsy}) \times 100\%$$

Explanation:

TPe = Effort level (%)

Ei = Fishing effort in year i (trip)

Emsy = Optimum fishing effort (trip)

## 3. Results and discussion

### 3.1. Purse seine ship

Vessels at PPN Tasikagung are typically 30 GT in size and approximately 15 to 25 metres in length. This capacity allows the vessels to carry more fish, with a catch capacity of 20 to 25 tonnes. These vessels are usually made of durable fibreglass or wood. Their aerodynamic design allows them to move quickly through the water.

**Figure 1** Fishing Vessel for *D. macrosoma*.

### 3.2. Fishing ground

Increasing production from fishing activities is highly dependent on the conditions of the fishing area, which is also influenced by various interrelated factors [22] purse seine has many fishing locations, where fish aggregating devices (FADs) are placed, manned by fishing masters who collect fish by installing attractors in the afternoon and lights at night, thereby attracting phototactic fish to gather. This is also confirmed by the research [23], assistant fishermen who guard the FAD's use raft houses as their place of residence, which are moored to the fish aggregating devices to guard or monitor the condition of the fish groups that gather there.

### 3.3 Biological and Economic Aspects of the *D. Macrosoma*

*3.2.1. Biological Aspects of the Shortfin scad (Decapterus macrosoma)*

The classification of the *D. macrosoma* is as follows [24]:

| | |
|---|---|
| *Phylum* | *: Chordata Subphylum* |
| *Actinopterygii Class* | *: Actinopterygii* |
| *Ordo* | *: Carangiformes* |
| *Family* | *: Carangidae* |
| *Subfamily* | *: Carangidae* |
| *Genus* | *: Decapterus* |


**Figure 2** *Decapterus macrosoma*

Based on the fishing season index graph for the period 2020–2024, the peak season occurs in five months of the year, namely August, September, October, November and December. The normal or usual season occurs in July, while the lean season occurs in six months, namely January, February, March, April, May and June.

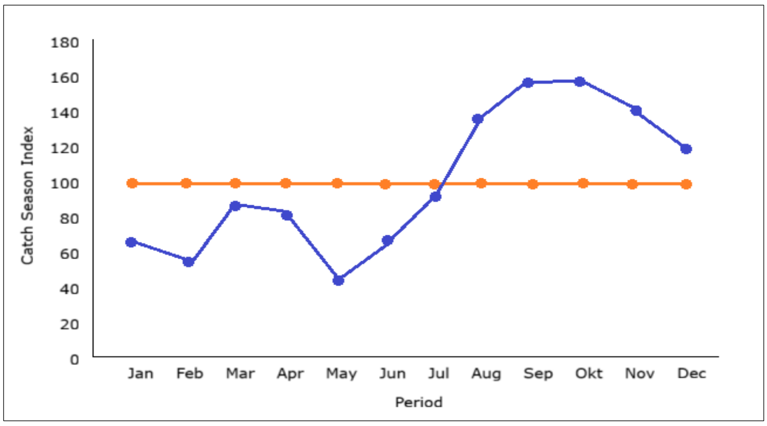


**Figure 3 D.** macrosoma fishing season graph

Based on the Fishing Season Index (FSI) calculation with the criteria, if the FSI is >100%, it is categorised as the fishing season (peak), but if the FSI value is <100%, it is categorised as not the fishing season (lean season), and if the FSI = 100%, it is categorised as normal or balanced (usual) [25].

*3.2.2. Economic Aspects of D. macrosoma*

Cost

Costs are the total expenses that must be incurred by fishermen in fishing activities. Total costs include fixed costs and variable costs. Fixed costs consist of investment costs, which include depreciation of vessels and engines, plus maintenance costs, while variable costs are operational costs, which include fuel costs and food and beverage costs [26]. The total costs of the *D. macrosoma* Fishing Business in Rembang, particularly at the PPN Tasikagung, are presented in the following table 2 and 3 below.

**Table 2** Investment costs

| No. | Vessel Name | Investment cost (Rp) | Depreciation/year (IDR) | Maintenance cost/year (IDR) |
|---|---|---|---|---|
| 1 | Ship 1 | 785,000,000 | 1,491,071 | 10,000,000 |
| 2 | Ship 2 | 630,000,000 | 1,087,302 | 13,000,000 |
| 3 | Ship 3 | 680,000,000 | 1,196,013 | 11,000,000 |
| 4 | Ship 4 | 785,000,000 | 1,355,519 | 10,000,000 |
| 5 | Ship 5 | 680,000,000 | 1,123,512 | 12,000,000 |

| | | | | |
|---|---|---|---|---|
| | x̄ | 712,000,000 | 1,250,684 | 11,200,000 |

**Table 3** Cost per Trip

| No | Operational Cost (Rp) | Cost (Rp/Trip) | Maintenance Cost (Rp) | Total Cost (Rp) |
|---|---|---|---|---|
| 1 | Minimum | 8,860,000 | 250,000 | 790,250,000 |
| 2 | Maximum | 8,860,000 | 325,000 | 695,325,000 |
| 3 | x̄ | 8,860,000 | 287,500 | 742,787,500 |

Purse seine fishing operations last 5-7 days per trip, depending on the catch. This fishing gear operates according to the season. During the lean season, fishermen do not go to sea and operate fishing gear, because the catch will be small or even non-existent. During the normal season, purse seine fishing operates up to 4 times a month. During the peak season, it operates up to 5-6 times. In one year, this fishing gear can operate up to 40 times or more.

The costs incurred by each fisherman vary depending on the number of crew members and the fishing area targeted, and the results are adjusted according to the needs required. The difference in fixed costs can be caused by differences in fixed and variable costs, including differences in investment costs, economic life, number of crew members, and others. Investment costs consist of the purchase of boats, fishing gear, and engines, while operational costs consist of the purchase of fuel, ice, and oil [27].

Revenue

Revenue from *D. macrosoma* fishing operations is derived from the sale of catches obtained on each trip. This revenue is gross revenue because it has not been reduced by the operational costs incurred on each trip. The revenue of *D. macrosoma* fishermen varies, with many factors influencing it, namely differences in the amount of catch.

The price per kilogram of *D. macrosoma* ranges from IDR 3,000 to 10,000. The price of *D. macrosoma* can vary depending on the fishing season. In addition, the season also affects revenue. This is due to seasonal factors. During the lean season, the average catch is only 495 kg, while during the normal season it reaches 1,293 kg and during the peak season it can reach 2,734 kg. This causes fluctuations in the price of , which in turn leads to a decline in fishermen's income. Details of the catch for each season can be seen in the table below. The fishing locations of the vessels below are in close proximity, meaning they are in the same area.

**Table 4** Average catch per season

| | **Catch (Kg)** | | |
|---|---|---|---|
| Vessel name | Peak (6 months) | Normal (1 month) | Off-peak (5 months) |
| Ship 1 | 2,300 | 1,433 | 500 |
| Ship 2 | 4,596 | 1,088 | 500 |
| Ship 3 | 2,478 | 1,609 | 500 |
| Ship 4 | 2,164 | 1,209 | 500 |
| Ship 5 | 2,132 | 1,125 | 476 |
| x̄ | 2,734 | 1,293 | 495 |

**Table 5** Revenue

| Season | Average Catch (kg) | Average income (Rp) |
|---|---|---|
| Peak | 2,734 | 27,340,000 |
| Normal | 1,293 | 12,930,000 |
| Famine | 495 | 4,950,000 |
| Total | 4,522 | 45,220,000 |
| $\bar{x}$ Fish Price | | 10,000 |

Revenue from *D. macrosoma* fishing operations is derived from the sale of catches obtained during each trip. This revenue is gross revenue because it has not been reduced by the operational costs incurred during each trip. Revenue varies, with many factors influencing it, namely differences in the amount of catch. The catch obtained by fishermen during the peak season can reach 10,210 kg.

*3.2.3. Marketing Pattern of D. macrosoma*

At the PPN Tasikagung, the marketing of *D. macrosoma* is carried out in such a way that the boat owners or fishermen do not deal directly with the end consumers in distributing the fish catch, but rather with collectors and factories, which are the direct consumers for the fishermen or boat owners. Therefore, the technicalities or sales patterns at each port are different. At the PPN Tasikagung, the marketing pattern can be seen below:

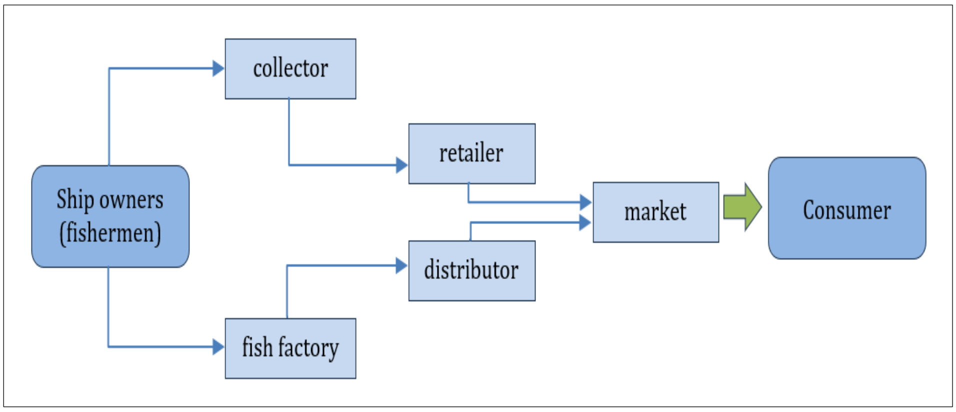


**Figure 4** Marketing Distribution Flow

*3.2.4. Production and Production Value of D. macrosoma at PPN Tasikagung*

The production volume and production value of capture fisheries, particularly for *D. macrosoma* in Rembang Regency from 2020 to 2024, are presented in the following table 6 and figure below:

**Table 6** Production and Production Value of *D. macrosoma* at PPN Tasikagung

| Year | Production | Production Value |
|---|---|---|
| 2020 | 19,029,146 | 155,847,131,000 |
| 2021 | 12,201,903 | 218,892,586,000 |
| 2022 | 16,035,459 | 183,639,167,000 |
| 2023 | 24,354,222 | 209,230,332,000 |
| 2024 | 1,220,061 | 6,796,069,300 |

Source: Rembang District Statistics Agency (2020-2024)

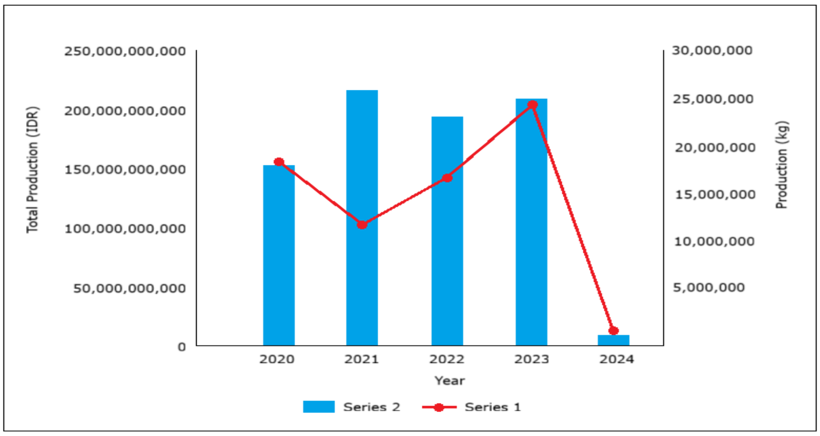


**Figure 5** Graph of Production (kg) and Production Value (Rp) of *D. macrosoma.*

It is known that the production of *D. macrosoma* in Rembang Regency has fluctuated over the last 5 years. The highest production occurred in 2023, amounting to 24,354,222 kg, while the lowest production occurred in 2024, amounting to 1,220,061 kg. The highest production value of *D. Macrosoma* occurred in 2021, amounting to IDR 218,892,586,000, while the lowest production value occurred in 2024, amounting to IDR 6,796,069,300.

### *3.2.5. Fishing Units at PPN Tasikagung*

The types of fishing gear are used at PPN Tasikagung. The number of fishing gear used from 2014 to 2024 is presented in Table 7.

**Table 7** Fishing Units at PPN Tasikagung

| Fishing Gear | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|
| Purse seine | 97 | 104 | 110 | 122 | 143 |
| Trawl (Ice) | 349 | 365 | 375 | 398 | 411 |
| Trawl (Freezer) | 351 | 361 | 366 | 387 | 343 |
| Bottom longline | 3 | 3 | 3 | 3 | 3 |
| Seine net | 64 | 70 | 75 | 79 | 82 |

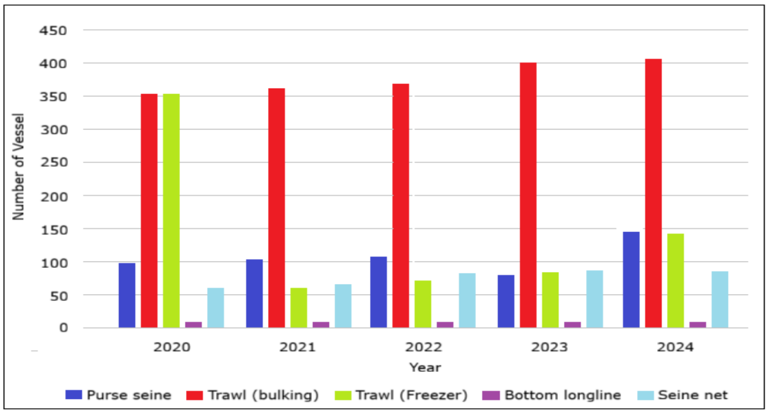


**Figure 6** Diagram of Fishing Units in PPN Tasikagung Rembang

Based on Figure 6, the fishing gear used by PPN Tasikagung fishermen varies. Fishing units have increased from year to year, with 864 units in 2020 and 982 units in 2024. The dominant fishing gear is trawl, seine net and Purse Seine.

Purse seine is an environmentally friendly fishing gear that is also easy to operate. In addition, the materials used to make this fishing gear are readily available, which is why many fishermen use purse seine to catch fish. Although Purse Seine is widely used, its long-term use will lead to an increase in production, which will certainly have a negative impact on resources. The efficient use of production factors is therefore essential. Excessive use will hinder the achievement of optimal production results [28].

Catch Per Unit Effort (CPUE)

With the data on the number of fishing gear and the number of trips made each year, as well as the production of *D. macrosoma,* the CPUE value can be calculated, as shown in the following table:

**Table 8** Catch Per Unit Effort (CPUE) Values

| Year | Effort (trips (X)) | Catch (production (Y)) | CPUE (Y) |
|---|---|---|---|
| 2020 | 487 | 19,029,146 | 39,074 |
| 2021 | 342 | 12,201,903 | 35,678 |
| 2022 | 544 | 16,035,459 | 29,477 |
| 2023 | 615 | 24,354,222 | 39,600 |
| 2024 | 572 | 1,220,061 | 2,133 |
| Average | 512 | 14,568,158 | 29,193 |

Table 13 shows that based on the known production figures for each year, the productivity of *D. macrosoma* itself fluctuates annually. The known increases and decreases in CPUE figures may be attributed to seasonal factors, which result in many purse seine vessels arriving from other areas, as the Tasikagung area has high potential for *D. macrosoma* catches. Efforts related to fishing and CPUE illustrate the productivity level of Purse Seine fishing gear in catching D. macrosoma, with an average catch per unit of fishing effort during the 2020–2024 period of 14,568,158 kg/year.

The lowest CPUE occurred in 2024, which was 2,133, indicating that in that year, the catch was low, but the fishing effort was relatively high. The correlation between CPUE and *D. macrosoma* fishing effort shows a negative relationship, i.e., the higher the fishing effort, the lower the CPUE value. The negative correlation between CPUE and fishing effort indicates that the productivity of purse seine fishing at PPN Tasikagung will decline if fishing effort increases.

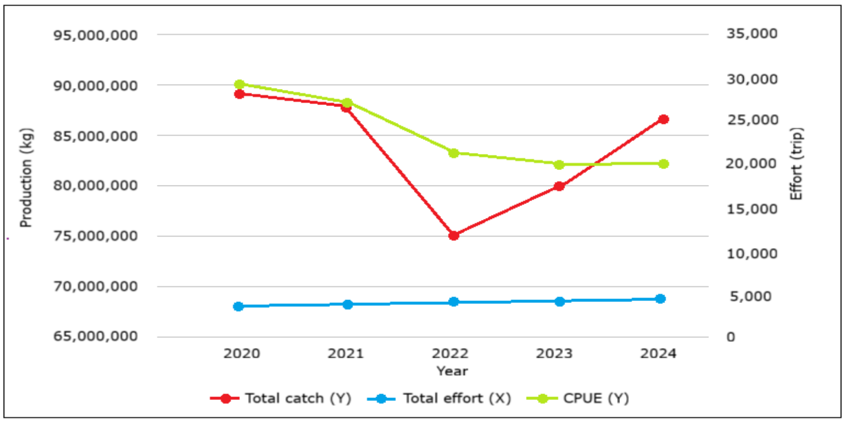


**Figure 7** Graph of production value (Y), number of trips (X), and CPUE of *D. macrosoma.*

The catch per unit of fishing effort, or CPUE, reflects the ratio between the catch and the fishing effort expended. In principle, the catch is the output of fishing activities, while the effort required is the input of those activities. In economic terms, the ratio between output and input reflects the technical efficiency level of each input use. Therefore, CPUE can also be used as an indicator of the technical efficiency level of effort use.

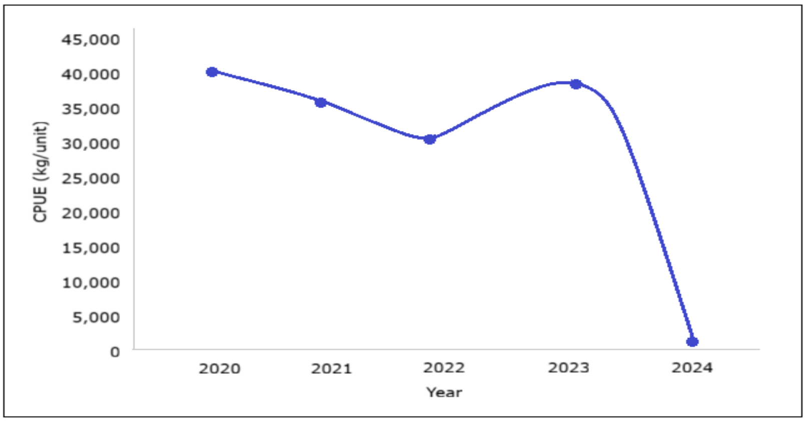


**Figure 8** CPUE graph per year

Based on Figure 8, the highest CPUE value occurred in 2023, which was 39,600 kg/unit, meaning that in 2023, the catch of *D. macrosoma* was highest, but fishing effort was low. The lowest CPUE occurred in 2024 at 2,133 kg/unit, meaning that in that year, the catch of *D. macrosoma* was low but fishing effort was high. The high and low CPUE can be caused by the addition or reduction of fishing gear. The declining CPUE value indicates the occurrence of overfishing. This is in line with the statement that the characteristics of a fishing industry are heading towards overfishing, including longer fishing times, fishing locations tending to be further away, declining productivity/catch rate (CPUE), smaller target fish sizes, and increasing fishing operation costs [29].

Fish production is decreasing. This is because the waters in Rembang Regency have experienced overfishing. Open access waters make it difficult to estimate fish stocks, so fish stocks cannot be controlled. Excessive fishing is a form of exploitation of fish populations. If fish resources continue to decline, the growth rate of fish will slow down. This condition certainly requires proper management of fishing efforts, so that optimal catches can be achieved. Based on the CPUE calculations above, the graph showing the relationship between CPUE and trips is presented in the following figure.

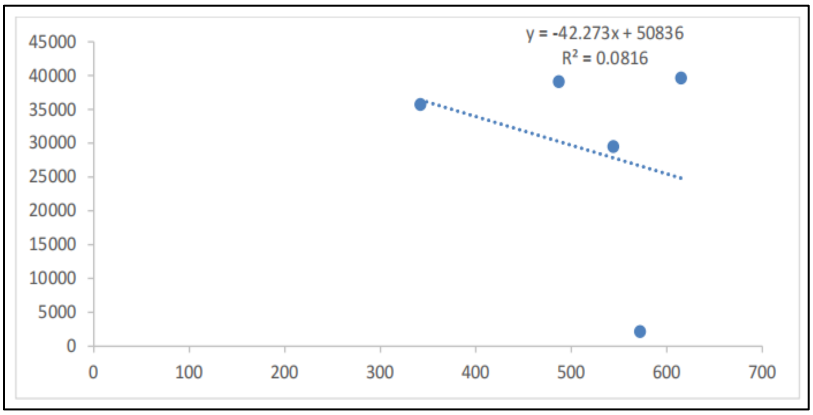


**Figure 9** Graph of the Relationship between Effort and CPUE

Based on Figure 9, the figure shows a graph of the relationship between effort and CPUE, which produces a linear equation of CPUE = -42,273x + 50,836 with $R^2$ = 0.0816. This equation shows that:

The regression constant (b) = -42,273 indicates a positive relationship between CPUE and effort, meaning that every 1 unit increase in effort will cause CPUE to decrease by 42,273 kg/unit of fishing gear. This indicates that the higher the fishing effort, the lower the catch efficiency per unit, which could be an early sign of a decline in fish stocks.

The coefficient of determination $R^2$ = 0.0816 or 8.16%. This indicates that 8.16% of the variation or fluctuation in CPUE is influenced by fluctuations in effort, while the remaining 91.84% is caused by other factors (weather, fish prices).

### 3.3. Bioeconomic Analysis Using the Gordon-Schaefer Model

Bioeconomic analysis is an analysis to measure the level of utilisation of fishery resources from biological and economic aspects. This analysis uses time series data on production and effort. The Gordon-Schaefer bioeconomic model is one type of bioeconomic analysis that combines economic factors affecting capture fisheries and biological factors determining fish production and stocks in nature [30].

**Table 9** Bioeconomic Value Using the Gordon-Schaefer Model

| | MSY | MEY | OAE |
|---|---|---|---|
| C | 15,283,570 | 15,283,338 | 237,371 |
| E | 601 | 599 | 1,198 |
| TR | 56,623,078,653 | 56,622,218,311 | 879,419,811 |
| TC | 441,430,591 | 439,709,906 | 879,419,811 |
| π | 56,181,648,063 | 56,182,508,405 | 0 |

The bioeconomic analysis of *D. macrosoma* in Rembang Regency, more precisely in PPN Tasikagung, using the Gordon Schaefer model, reached MSY conditions with a catch (CMSY) of 15,283,570 kg/year and an Effort ($E_{MSY}$) value of 601 fishing gear units/year with a profit of IDR 56,181,648,063 The MEY condition was obtained when the catch value ($C_{MEY}$) was 15,283,338 kg/year and the effort value ($E_{MEY}$) was 599 fishing gear units/year, with a profit of IDR 56,182,508,405. The OAE condition is obtained when the catch ($C_{OAE}$) is 237,371 kg/year and the effort ($E_{OAE}$) is 1,198 fishing gear units/year, with a profit of 0. If it reaches 0, it means that the costs incurred are equal to the value of the revenue received.

Based on bioeconomic calculations, the effort during MSY conditions is greater than the effort during MEY conditions, so that the total cost (TC) incurred during MEY is smaller than during MSY conditions. A profit of 0 is the break-even point, meaning that fishing for *D. macrosoma* is neither profitable nor loss-making. If it reaches 0, it means that the costs incurred are equal to the value of the revenue received. The bioeconomic equilibrium point graph for D. macrosoma, using the Gordon-Schaefer model, is presented in the figure below:

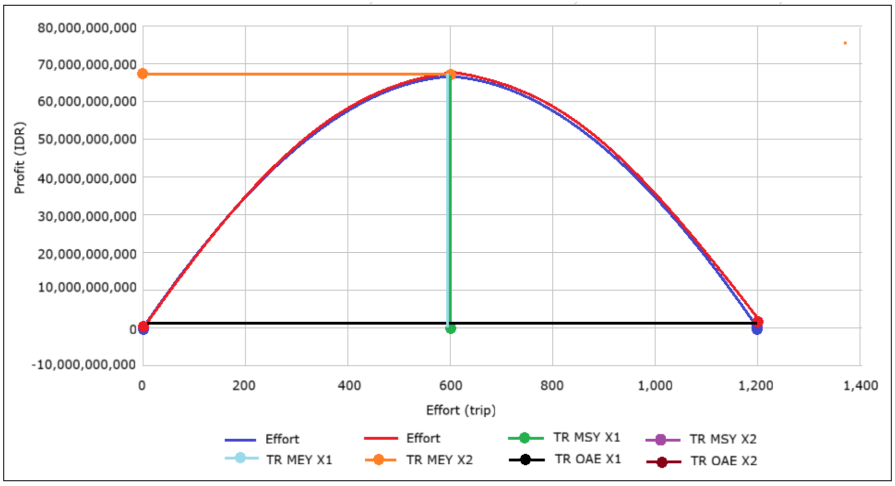


**Figure 10** Bioeconomic Equilibrium Point Graph for *D. macrosoma*

Figure 10 Bioeconomic Equilibrium of the Gordon Schaefer Model Based on the figure, the $TR_{MSY}$ condition is greater than the $TR_{MEY}$ and the $TC_{MSY}$ is greater than the $TC_{MEY}$. The MEY point is the optimal point when the MEY production obtained is high, but the fishing effort is less than the MSY condition, thus enabling large revenues and greater profits to be obtained. The profit obtained under MEY conditions is IDR. 56,182,508,405, while the profit under MSY conditions is IDR 56,181,648,063.

This indicates that under MEY conditions, the profits from *D. macrosoma* fishing operations are at their maximum. The bioeconomic equilibrium point graph using the Gordon-Schaefer model with the MSY peak point. If the effort exceeds the MSY effort value, the production will decrease to 0. The peak profit is obtained at the MEY peak point, but if the effort value exceeds the MEY effort value, the profit will decrease.

### 3.4. Maximum Sustainable Yield (MSY)

Base on the results of MSY analysis using the Gordon-Schaefer model, the catch at $C_{MSY}$ conditions is 15,283,570 kg per year, while the $E_{MSY}$ value is 601 fishing gear units per year.

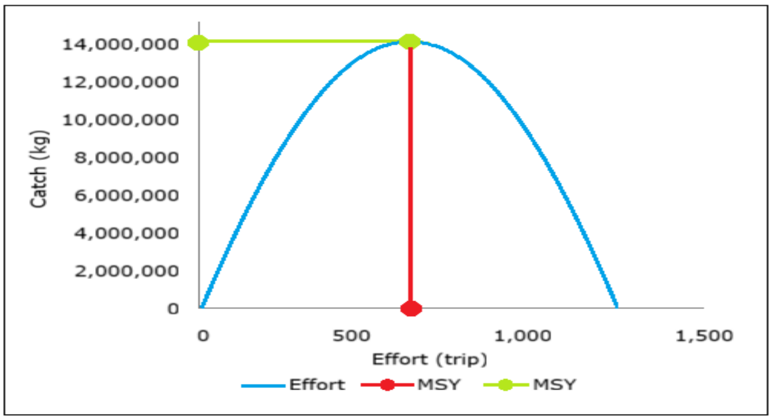


**Figure 11** MSY Graph

As shown in Figure 11 above, there are known values during the calculation using the Gordon-Schaefer model, namely the value of TR of IDR 56,623,078,653 and TC of Rp 441,430,591 months. From this analysis, we can predict that the profit could reach IDR 56,181,648,063 by looking at the figure above. We can see the balance in all the events that can be predicted, such as overfishing or further efforts, and it could be as usual.

### 3.5. Maximum Economic Yield (MEY)

MEY is a condition of catch utilisation that prioritises economic profit while maintaining the sustainability of fish resources and the environment. Based on the results of the MEY analysis of *D. macrosoma* resources using the Gordon-Schaefer model, MEY occurs when the utilisation resources reaches 15,283,338 kg/year. Fishing efforts will reach $C_{MEY}$ if there are 599 fishing gear units per year. The MEY analysis results show a total revenue (TR) of IDR 56,622,218,311 and fishing costs (TC) of IDR 439,709,906, resulting in a profit of IDR 56,182,508,405.

The catch under MEY conditions is lower than the catch under MSY conditions, but MEY conditions can generate the highest profit. The income obtained from fishing for Decapterus spp. is greater than the fishing costs, so fishermen will obtain a large profit at the $E_{MEY}$ point. Bioeconomic analysis shows that MEY is in better condition because this management yields lower TC and effort values, but higher economic rent compared to MSY [31]. This is consistent with the statement that a high economic rent indicates that at this production level, fishing effort has been carried out efficiently, resulting in better catches and subsequently maximum profits. This study found that the actual effort value was greater than the MEY effort and the MSY effort [32].

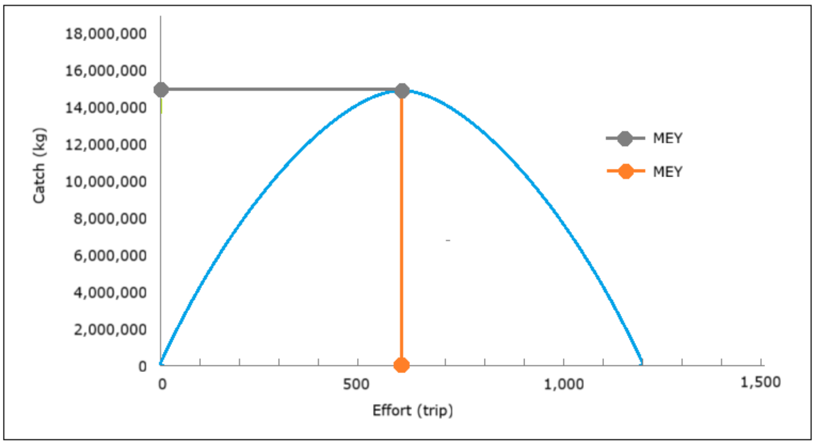


**Figure 12** MEY Graph

In Figure 12, we can conclude that the TR analysis value is IDR 56,622,218,311 and the TC value is IDR 439,709,906, yielding a profit of IDR 56,182,508,405 as stated above. If MEY seeks the lowest point of capture or what we can call garch, it is optimised to capture greater profits in the MSY and OAE analyses.

### 3.6. Open Access Equilibrium (OAE)

OAE is an open equilibrium that occurs during open access fishing activities. Fishing that has exceeded the OAE value no longer has any benefits. OAE conditions occur when fishing efforts are at a break-even point or are not profitable but also not detrimental. If fishing at the OAE point continues, losses will occur where expenditure costs will be greater than income costs. The OAE condition is a worrying condition because in this condition, fishing operations can go bankrupt and natural resources can become depleted. OAE is a condition of open access equilibrium where, in carrying out fishing operations, the amount of costs incurred will be equal to the amount of total revenue, so that the amount of profit is £0. The OAE condition shows that the number of fishing units is far greater than in the MSY or MEY conditions, so that total revenue will continue to decline until fishermen no longer make a profit.

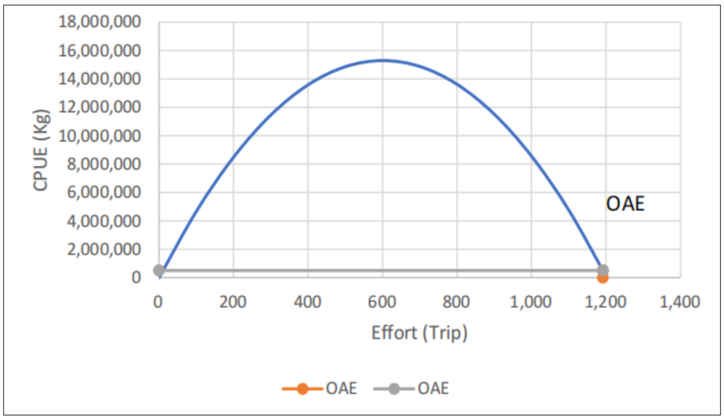


**Figure 13** OAE Graph

Figure 13 above emphasises that the OAE point will produce a value where the OAE analysis is worth TR of

IDR 879,419,811 and a TC value of IDR 879,419,811, resulting in a profit of IDR 0. Therefore, if fishing efforts are increased beyond those already described above, losses will occur, and minimal income or even losses may be incurred during that period.

### 3.7. Utilisation Rate and Effort

According to [33] the utilisation rate is calculated by presenting the total catch each year against the TAC (Total Allowable Catch) or the allowable amount of 80% of the maximum sustainable yield (CMSY). The utilisation rate and exploitation rate of the D. macrosoma. fish resources in Rembang District are presented in Table 10.

**Table 10** Utilisation and exploitation rates

| Year | Actual Production | CMSY | Emsy | Actual effort | Level Utilisation | Level Efforts |
|---|---|---|---|---|---|---|
| 2020 | 19,029,146 | 15,283,570 | 601 | 487 | 125% | 81% |
| 2021 | 12,201,903 | 15,283,570 | 601 | 342 | 80 | 57% |
| 2022 | 16,035,459 | 15,283,570 | 601 | 544 | 105% | 90% |
| 2023 | 24,354,222 | 15,283,570 | 601 | 615 | 159% | 102% |
| 2024 | 1,220,061 | 15,283,570 | 601 | 572 | 8% | 95% |
| Average | 14,568,158 | | | 512 | 95 | 85% |
| JTB | | | | 12,226,856 | | |
| T utilisation | | | | 1.19 | | |

Based on Table 10, the highest utilisation rate of *D. macrosoma* resources occurred in 2023 at 159%, while the lowest utilisation rate occurred in 2024 at 8%. The utilisation rate is influenced by the annual production volume, the higher the production volume, the higher the utilisation rate. The utilisation rate of 1.19 indicates that the resource is fully exploited, and fishing efforts are maintained under strict monitoring.

The average resource utilisation rate for *D. macrosoma* is 95%, indicating that resources are close to overfishing. This is consistent with the analysis results, which show an average utilisation rate of 85%. The calculations in Table 10 show that Cmsy is 15,283,570, whereas according to Ministerial Regulation No. 19 of 2022 and the CCRF, the permitted catch is 80%. Therefore, based on the results of this study, overfishing can be said to have occurred.

Therefore, the measurements in this analysis method cover many aspects of sustainability and economics in the waters of PPN Tasikagung, with results that we can say are not constant, such as several years experiencing overfishing, namely in 2020, 2022 and 2023, all of which were above 80% and the highest in 2023, reaching a value of 159%, resulting in a decline in catch in subsequent years, with a utilisation rate of no more than 15%. This indicates that in that year, the *D. macrosoma* resource level declined after excessive overfishing in previous years, which is supported by the opinion of [34].

The average exploitation rate of *D. macrosoma* resources in Rembang waters is 85%. The exploitation rate is influenced by the number of fishing gear used; the more fishing gear used, the higher the exploitation rate. The average exploitation rate of *D. macrosoma* resources in Rembang is more than 100%, which threatens the resources and economy of fishing in the Tasikagung fishing area. This occurs because the fishing efforts carried out by fishermen are still considered to exceed the maximum potential in the field of *D. macrosoma* fishing itself each year. The average utilisation rate has exceeded the sustainable potential level, which is unfortunate because fishing that exceeds the sustainable resource potential level due to excessive catches has an impact on the economy and biology.

## 4. Conclusion

The conclusions that can be drawn based on the research are as follows:

- Based on the CPUE analysis, the average standard CPUE value for *D. macrosoma* is 29.197 kg/unit, the MSY value for *D. macrosoma* fishing is 15,283,570 kg/year with an $E_{MSY}$ of 601 units/year. The $C_{MEY}$ value is 15,283,338 kg/year with an EMEY of 599 units/year, and the MEY profit is IDR 56,182,508,405 per year. The $C_{OAE}$ value is 237,371 kg/year with an $E_{OAE}$ of 1,198 units per year. The profit for the OAE Analysis value is IDR 0.
- The utilisation rate of *D. macrosoma* resources fluctuates with an average of 95%, and the average exploitation rate is 85%. Analysis of the utilisation rate resulted in an effort of 1 .19, which means that PPN Tasikagung may be able to maintain its fishing gear and fleet, but with strict monitoring, as it is already classified as *over-exploited*, meaning that the resource stock has declined because the *D. macrosoma* resource has been exploited beyond its maximum sustainable yield, so the increase in fishing effort must be reduced.

## Compliance with ethical standards


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### *Disclosure of conflict of interest*

No conflict of interest to be disclose.

## References


[1] Latuconsina, H. (2010). Estimation of the potential and utilisation rate of shortfin scad (*Decapterus* spp) in the waters of the Flores Sea, South Sulawesi. Agrikan: Scientific Journal of Agribusiness and Fisheries 3(2), 47-54.

[2] Wahju, R. I., Zulkarnain, and Mara, K. P. S., (2011). Estimation of the fishing season for shortfin scad (*Decapterus* spp) landed at PPN Pekalongan, Central Java. BULETIN PSP 19(1), 105-113.

[3] Tiku, M., Krisnafi, Y., and Arkham, M. N. (2021). Performance of Mini Purse Seine and Cantrang in Coastal Fishery Port (PPP) Tasik Agung, Rembang Regency. Coastal and Ocean Journal (COJ) 5(1), 19–27.

[4] Fitriyashari, A., Rosyid, A., and Ayunita, D. (2014). Needs Analysis of Fishing Vessel Supplies at Tasikagung Fishing Port, Rembang. International Journal of Resources Utilisation Management and Technology 3(3), 122–130.

[5] Fauzi, M., and Bintoro, I. G. (2021). Management and Analysis of Purse Seine Fishing Businesses in Juwana, Pati Regency, Central Java (Doctoral dissertation, Brawijaya University).

[6] Wahyudi, A. D., and Syah, A. F. (2022). Sustainability Assessment of the Management of shortfin scad (*Decepterus* sp.) Catches in WPP 712, Northern Waters of Sumenep Regency. Juvenil: Journal of Marine Science and Fisheries 3(4), 151–158.

[7] Sangadji, J., Kusumastanto, T., and Simanjuntak, S. M. H. (2014). Analysis of Depreciation and Management Policies for *D. macrosoma* Resources in the Waters of Ambon City. Journal of Agriculture, Resource, and Environmental Economics (JAREE) 1, 43-60.

[8] FAO. (2022). The State of World Fisheries and Aquaculture 2022: Towards Blue Transformation. Rome: Food and Agriculture Organisation.

[9] Wiguna, M. E., and Yuarsa, R. A. (2018). Application of the Gordon-Schaefer Bioeconomic Model for Economic Feasibility Analysis of Drift-Gillnet Fishing in Indramayu Regency, West Java. AGROSCIENCE 2(1), 40-60.

[10] Demena, Y. E., Miswar, E., and Musman, M. (2017). The determination of potential fishing area of skipjack tuna (*Katsuwonus pelamis*) using satellite imagery in. 2 April 2016, Unsyiah Marine and Fisheries Student Scientific Journal 2(1), 194–199.

[11] Dewi, D. D. A. (2018). The sustainability of purse seine fishing in Pekalongan in terms of business efficiency. Akuatik: Journal of Water Resources. University of Bangka Belitung.

[12] Dewi, D. A. N., Wibowo, B. A., and Husni, I. A. (2017). Purse seine fishing sustainability at Pekalongan: an overview of technical efficiency aspects. Akuatik: Journal of Water Resources 11(2), 7–13.

[13] Kurman, M., Suharyanto, and Baskoro, M. S. (2024). Management of Purse Seine Fishery in Larantuka Waters East Flores District, East Nusa Tenggara Province. Albacore 8(3), 289-302.

[14] Dewanti, L. P., Sienna, Y. I., Khan, A., Apriliani, I. M., and Herawati, H. (2020). Selectivity of Gillnet Capturing L. savala (*Trichiurus lepturus*) Resources in Pangandaran Regency. Albacore 3(3), 273–281.

[15] Utami, D. P., Gumilar, I., and Sriati. (2012). Bioeconomic Analysis of Ribbonfish (*Trichiurus* sp.) Catch in Parigi Waters, Ciamis Regency. Journal of Fisheries and Marine Affairs 3(3), 137–144.

[16] Hakim, L. L., Anna, Z., and Junianto. (2014). Bioeconomic Analysis of Narrow-barred Spanish Mackerel (*Scomberomorus commerson*) in the Waters of Indramayu Regency, West Java. Sosek KP Policy Journal 4(2), 117-127.

[17] Sari, N., and Dewi, D. A. N. N. (2014). Bioeconomic Analysis of the Gordon Schaefer Model of Wader Fish (*Rasbora* sp) Resources in Rawa Pening, Semarang Regency. Journal of Fisheries Resources Utilisation Management and Technology 3(3), 62-70.

[18] Susanto, B., Anna, Z., and Gumilar, I. (2015). Bioeconomic Analysis and Management of Carp (*Cyprinus carpio*) Resources in Cirata Reservoir, West Java. Journal of Fisheries and Marine Sciences 6(2), 32–42.

[19] Haryanto, T., Rahmawati, Y., Kusumawardani, D., Martina, A., Ichsan A. K. N., Erlando, A., and Ibrahim, K. H. (2025). Balancing economic benefits and conservation: A bioeconomic assessment of *Sardinella lemuru* fisheries management in Muncar, Banyuwangi, Indonesia. Open Social Sciences and Humanities (DeepL) 11, 1–9.

[20] Hutubessy, G. (2022). Composition of fishing catches in Kaiwatu, Southwest Maluku Regency. Unram Fisheries Journal 12(2), 233-244.

[21] Akbar, M. A., Rasyid, A., and Nelwan, A. F. P. (2023). The Level of Utilisation of Small Pelagic Fish Resources in Buton Regency, Southeast Sulawesi. Torani 6(2), 102-118.

[22] Yusrizal, Y., Kusumo, T., and Rachmalio, M. F. (2022). Study of Purse Seine Catches Reviewed from Fishing Areas on KM. Anugrah in the Banda Sea Region FMA-RI 714. Journal of Applied Marine Affairs and Fisheries (JKPT) 4(2), 127.

[23] Purba, N. P., Pratama B. B., Dewanti, L. P., Harahap, S. A., Febriani, C., Ilmi M. H., Mahendra, M. R. A., Madihah, J. S., and Khan A. M. A. (2024). Examining fishing activities based on in-situ tracking and oceanographic characteristics in Aru Sea and surroundings. Journal of Sea Research 202, 1-10.

[24] Saanin, H. (1984). Taxonomy and Identification Key of Fish, Jakarta: Bina Cipta 508 p.

[25] Hamka, E., and Rais, M. (2017). Determination of the Fishing Season for shortfin scad (*Decapterus* sp.) in the Eastern Waters of Southeast Sulawesi. Journal of Science and Technology in Fisheries Resource Utilisation 3(6), 510-517.

[26] Gunawan, M., Ernaningsih, D., and Khairul, A. (2022). Bioeconomic Analysis of Yellowfin Tuna (*Thunnus albacares*) at Palabuhanratu Fishing Port. Satya Minabahari Scientific Journal, 7(2): 20-31.

[27] Yahya, C. M. (2020). Static and Dynamic Bioeconomic Analysis of the Management of Banana Cigar Mackerel Resources in Tulungagung Waters (Case Study of PPP Popoh, Tulungagung) (Doctoral Dissertation, Brawijaya University) 2(1), 40-60.

[28] Hadi, A., Mutamimah, D., and Wardhana, M. G. (2020). Analysis of Fish Catch Data at the Tasikagung Nusantara Fishing Port Technical Implementation Unit. Shortfin scad (*Decapterus* spp) Journal, 2(1): 1-5.

[29] Wang, J., Jiang, Y., Zhang, J., Chen, X., and Kitazawa, D. (2020). Catch per unit effort (CPUE) standardisation of Argentine shortfin squid (*Illex argentinus*) in the Southwest Atlantic Ocean using a habitat-based model. International Journal of Remote Sensing 41(24), 9309–9327.

[30] Tumion, F. F., Sadri, Risko, Setiawan, H. P., and Julkipli. (2023). Composition of Main Catch in Gill Nets in the Natuna Sea. MANFISH Journal Marine, Environment and Fisheries. 4(2), 104-110.

[31] Rahmawati, M., Fitri, A. D. P., and Wijayanto, D. (2013). Analysis of Catch Results per Fishing Effort and Fishing Season Patterns for Anchovy (*Stolephorus* spp.) in Pemalang Waters. Journal of Fisheries Resources Utilisation Management and Technology 2(3), 213-222.

[32] Mayalibit, D., Kurnia, R., and Yonvitner. (2014). Bioeconomic analysis for management of yellowstripe scad (*Selaroides leptolepis*, Cuvier and Valenciennes) landed in Karangantu, Banten. International Journal of Bonorowo Wetlands 4, 49-57.

[33] Arifin, A. M., Pujiastuti, H., and Sudiana, R. (2020). Development of STEM learning media with augmented reality to improve students' mathematical spatial abilities. Journal of Mathematics Education Research 7(1), 59–73.

[34] Listiyani, A., Wiajayanto, D., and Budi, B. J. (2017). Analysis of CPUE (Catch Per Unit Effort) and the Level of Utilisation of Lemuru Fish Resources (*Sardinella lemuru*) in the Waters of the Bali Strait. Indonesian Journal of Capture Fisheries 1(1), 9–17.