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Study of Bali Sardinella Stock (*Sardinella lemuru*) Landed at Nusantara Fishing Port (PPN) Pengambengan, Bali – Indonesia

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Abstract

Bali sardinella (*Sardinella lemuru* ~~*Lemuru*~~) is a type of small pelagic fish that has important economic value in Indonesia. In Indonesia, this fish is widely used to be processed into pindang fish, sardines and fishmeal. *Sardinella lemuru* is a pelagic fish found in shallow sea waters, lives in groups, and is a surface species. The suitable habitat for *Sardinella lemuru* is coastal waters, the largest population of *Sardinella lemuru* in Indonesia is in the Bali Strait. Sustainable utilization of fishery resources must be immediately applied to resources that are already fully exploited. If this is ignored, fishery resources will become over exploited and even decrease drastically due to uncontrolled levels of exploitation that exceed the carrying capacity of the fishery resources. The ability of fishery resources to renew themselves through growth and recruitment is greatly influenced by the surrounding environment in terms of food resource procurement, competition between and between species, a healthy and suitable environment and the presence of predators. This research was conducted from February 15 to May 15, 2024 by conducting fishing operations using a mini purse seine vessel in the waters of the Bali Strait. The tools and materials used include ships, fishing gear, meters, cameras, navionic applications, and stationery. The purpose of this study was to analyze the potential stock of *Sardinella lemuru* landed at Nusantara Fishing Port (PPN) Pengambengan. It is hoped that this study can provide information on the potential stock of sustainable *Sardinella lemuru* based on the length distribution and surplus production model approach at PPN Pengambengan Bali. The graph of the relationship between effort and CPUE produces a linear equation CPUE = -0.0001x + 2.6736 with R2 = 0.0317, this equation shows that the CPUE trend decreases along with the addition of effort value each year, this indicates that the level of fishing effort is getting higher. The CMSY value shows the maximum sustainable production level, namely the highest *Sardinella lemuru* yield, while the EMSY value shows the optimum level of effort. The results of the average utilization rate show that the utilization of *Sardinella lemuru* resources has achieved optimum utilization, with an average of 71%. Fishing efforts exceeding EMSY may threaten *Sardinella lemuru* resources in the Bali Strait.

Keywords: *Sardinella lemuru*; CPUE; MSY; Over Exploited; Composition

1. Introduction

The Bali Strait is a strait that separates Java Island and Bali Island, so that the Bali Strait intersects two provinces, namely East Java Province and Bali Province [1]. The Bali Strait is one of the waters in Indonesia that has the potential for fish resources and is included in WPP-RI 573. One of the fish resources in the Bali Strait Waters that has quite high potential and economic value is Bali sardinella (*Sardinella lemuru*) [2]. This fish is a fishery resource that has a very strategic role, including as: 1) the main source of income for local fishermen; 2) mobilization of regional economic activities, especially in absorbing labor in various business fields, namely fishing businesses, processing industries, transportation service

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industries and marketing of fishery products; 3) providers of raw materials for processing industries; 4) sources of local revenue (PAD) [3]. The form of *Sardinella lemuru* is as shown in Figure 1 below.

[4] (Puspitarini, 2021)

Figure 1 Bali Sardinella (*Sardinella lemuru*)

Sardinella lemuru is a type of small pelagic fish that has important economic value in Indonesia [5]. In Indonesia, this fish is widely used to be processed into pindang fish, sardines and fishmeal [6]. *Sardinella lemuru* is a pelagic fish found in shallow sea waters, lives in groups, and is a surface species. The suitable habitat for this fish is coastal waters, and the largest population of this fish in Indonesia is in the Bali Strait [7].

Sustainable utilization of fishery resources must be immediately applied to resources that are already fully exploited. If this is ignored, fishery resources will become overexploited and even decrease drastically due to uncontrolled levels of exploitation that exceed the carrying capacity of these fishery resources [8]. The ability of fishery resources to renew themselves through growth and recruitment is greatly influenced by the surrounding environment in terms of food resource provision, competition between and among species, a healthy and suitable environment and the presence of predators [9]. The purpose of this study was to analyze the potential stock of *Sardinella lemuru* landed at PPN Pengambengan. It is hoped that this study can provide information on the potential sustainability of *Sardinella lemuru* based on the length distribution and surplus production model approach at PPN Pengambangen Bali and can be used as a reference for further research.

2. Material and methods

This study was conducted from February 15 to May 15, 2024 by conducting fishing operations using a mini purse seine vessel in the waters of the Bali Strait. The tools and materials used in this study include ships, fishing gear, stationery, meters, cameras, and the Navionic application.

2.1. Data Collection Methods

The data collection method used in this study is observation, observation is a field activity on *Sardinella lemuru* samples as the main object of observation. During data collection, data was recorded with stationery and recorded with a digital camera. In this study, 2 types of data were used, namely primary data and secondary data.

2.1.1. Primary data

Primary data is data obtained directly from observations. Observations include following fishing boats in the fishing process to the fishing ground using small pelagic purse seine fishing gear. Furthermore, measuring the fish caught which is measured from the tip of the front mouth to the tip of the outer part of the curve of the caudal fin branch (fork length) [10]. This approach allows for accurate data collection on the size and number of catches that are important for fish stock analysis [11].

2.1.2. Secondary data

Secondary data is supporting data in this study in the form of data obtained from fishing port management officers and data from the PPN Pengambengan ~~Nusantara Fisheries Port (PPN)~~, including production data (catch), and data related to supporting the capture fisheries sector. Supporting data for this study were also obtained from journals, articles, literature, or previous research related to this study [12].

2.2. Data Analysis Methods

2.2.1. Composition of Catches

The composition of the types of catches is calculated based on the composition of each hauling time with units (kg/ton) of fish types, the composition of the catch is carried out by grouping the catches from the dominant species caught on each purse seine vessel. Then it is added up per month to calculate the percentage of each species caught [13] the calculation uses the following

$$P = \frac{N1}{N} \times 100\%$$

Description

P = Percentage of one type of fish caught
N1 = number of fish caught 1 (Kg)
N = Total number of catches (Kg)

In this study, the composition of the *Sardinella lemuru* catches followed during the study was also calculated to see the number of catches [14].

2.2.2. Potential Stock of Sardinella lemuru in the Bali Strait

The stock estimation analysis was taken from several sources of information to estimate the abundance of resources and population change trends. Basically, information is obtained from fishing vessels (commercial), for example the number of catches and Catch Per Unit Effort (CPUE) are basic data for stock assessments [15].

The method that produces good and efficient estimates is to analyze the relationship between fishing effort and CPUE. From this analysis, the stock value and sustainable catch potential (MSY) will be obtained, namely the maximum catch weight that does not endanger the sustainability of fishery resources [16].

The stages carried out are the first to find secondary data in the form of data on efforts and catches of *Sardinella lemuru*. Next, look for primary data, namely measuring the fork length (FL) by following the fishing process using a small pelagic purse seine vessel. The data obtained are then processed using length frequency distribution analysis and production surplus analysis to obtain results and are discussed to produce a conclusion [17].

2.2.3. Length Frequency Distribution

To find out the length frequency distribution, *Sardinella lemuru* length data is needed here using the fork length (FL) type. Measurements are made using a ruler with an accuracy of 1 mm. These steps help in understanding the length distribution, which is important for population analysis and fish resource management [18]

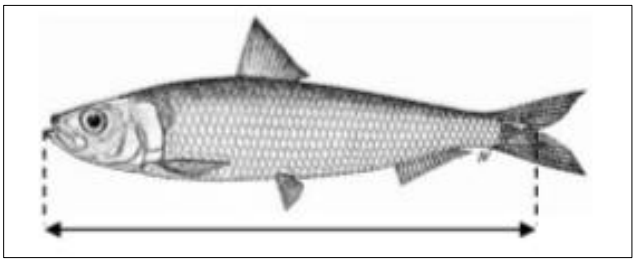

Figure 2 Fork Length (FL) Measurement

Furthermore, to determine the class interval in the distribution of length distribution (such as the fork length in *Sardinella lemuru*) in making a histogram is to use the Sturges model calculation as one of the commonly used methods [19]. The Sturges model calculation is to determine the number of classes ~~(bins)~~ in the *Sardinella lemuru* samples measured in this study.

2.2.4. Production Surplus Model

In calculating the Maximum Sustainable Yield (MSY), the Schaefer model approach is used. The steps taken are as follows

- Compiling production data in units of weight (tons) and fishing effort (effort) in trip units.
- Calculating Catch per Unit Effort
- Identifying Catch Maximum Sustainable Yield (CMSY) and Effort Maximum Sustainable Yield (EMSY) using the Schaefer model [20].

By using simple regression analysis of the existing time series data, the intercept (a) and slope (b) values can be calculated so that the maximum catch and optimal effort of the two models can be estimated [21]

$$\text{MSY} = \frac{a^2}{4b}$$

Description

a = Intercept Result;
b = Slope Result

The utilization rate results are calculated using the MSY value to determine the fishing capacity through the catch, with the formula [22]

$$\frac{x}{y}\ x\ 100\%$$

Description

x = Production result value;
y = MSY value

The Surplus Production Model (MPS) formulas are only valid if the slope parameter (b) is negative, meaning that increasing fishing effort will cause a decrease in CPUE. if the calculation obtains a positive slope (b) value, Descriptive Statistical Data Analysis is used to describe the time trend and variation in lemuru catches and CPUE during the study period. The MSY model was fitted to the data to determine the optimal fishing effort for lemuru in the Bali Strait waters. A comparison between the observed CPUE and the values predicted by the model was made to assess the agreement between the actual catch and the sustainable level [23].

Determination of MSY and optimum effort can only be done if the parameter b in the equation y = a + bx is negative, which means that additional effort will cause a decrease in CPUE. If the slope b is positive, then the amount of stock estimation or optimum effort cannot be determined, but it can only be concluded that additional effort can still be increased to increase catch production [24]. The utilization rate is determined by comparing last year's production with the availability of MSY obtained, so the formula for the utilization rate is as follows [25]:

$$\text{P} = \frac{\textbf{Catch}}{\textbf{MSY}} \text{ x } 100\%$$

Description

P = Utilization rate
MSY = maximum sustainable yield.

3. Results and discussion

3.1. Fishing Ground

Fishing ground in the WPP-RI 573 area, which are potential areas for fishing activities. Fishing operation areas that are often visited are around the Bali Sea, Bali Strait and Tanah Lot. The process of determining fishing areas is generally based on the experience of fishermen. The map of fishing areas and fishing positions can be seen in Figure 3.

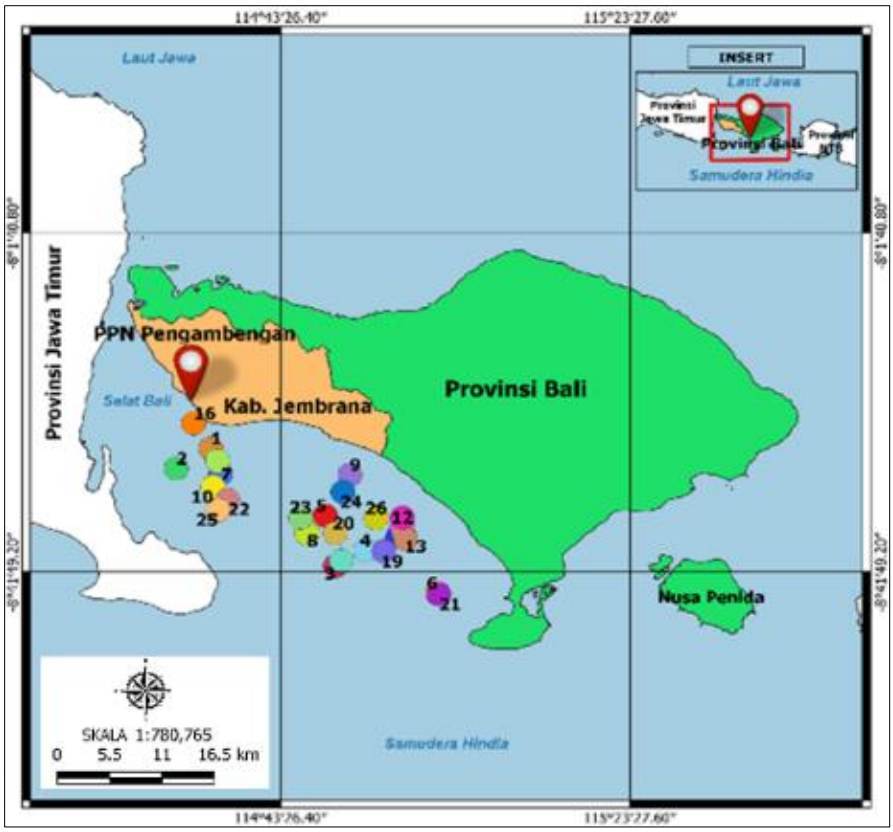

Figure 3 Fishing Area

3.2. Composition of Catch

In [26] The many types of purse seine catches are caused by several things;

- Related to the nature of fisheries in tropical areas which are multi-species, namely inhabited by various types of marine biota.
- The mesh size used for purse seine fishing operations is relatively very small, which allows catching other types of fish and small fish.
- The similarity of habitat between target and non-target fish which causes a variety of catches. The percentage of fish caught can be seen in table 1 below.

Table 1 Types and Catches

No	Species	Amount (kg)	Percentage (%)
1	Bali Sardinella (*Sardinella lemuru*)	80,043	92.41
2	Indian scad (*Decapterus spp*)	3,306	3.82
3	Mackerel Tuna (*Euthynnus affinis*)	3,266	3.77
	Total	86,615	100

Based on Table 1, the type of catch is 86,615 kg with the dominant type of catch being *Sardinella lemuru* as much as 80,043 kg, *Decapterus* spp. as much as 3,306 Kg, *Euthynnus affinis* as much as 3,266 kg.

3.3. Frequency Distribution of Length (Fork Length)

The number of *Sardinella lemuru* length data observed was 221 fish from the Bali Strait Waters catchment area which was landed at PPN Pengambengan, sampling was carried out every one fishing operation during March to May 2024. The results of this study show that:

The number of classes of the length of *Sardinella lemuru* measured was 9 classes

$$K = 1 + 3{,}3 \times LogN$$

$$K = 1 + 3{,}3 \times \ Log\ 221$$

$$K = 8{,}74$$

The inter-class interval of this study is 5

$$\mathrm{i} = \frac{N\ Max - N\ Min}{K}$$

$$i = \frac{178 - 138}{9}$$

$$i = 4{,}6$$

In the overall observation, *Sardinella lemuru* was found to be 138-178 mm length. The results of the analysis obtained the number of length classes in the overall observation of 9 classes. The highest number of length classes was in the 163-167 mm length class interval with a total of 49 fish, while the lowest number of length classes was in the 178-182 mm length class interval with a total of 5 fish.

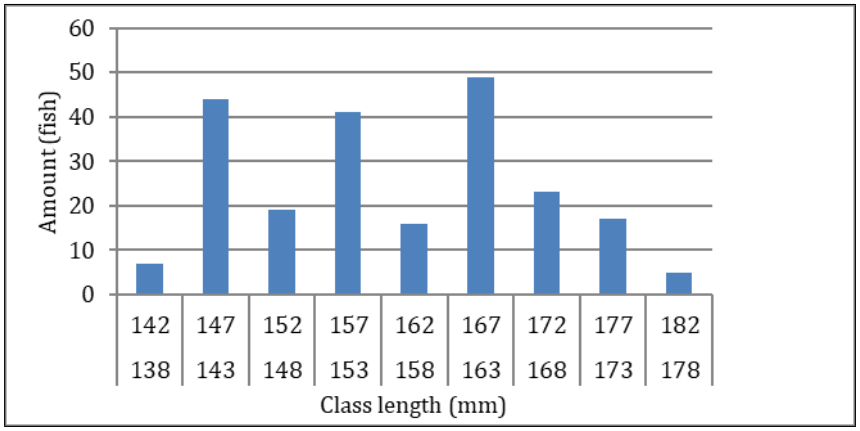

Figure 4 Fork length graph of *Sardinella lemuru*

The fork length of the *Sardinella lemuru* reaches gonad maturity for the first time at a length of 177 mm [27]. From the sampling data taken during this study with a total sampling of 221 fish, *Sardinella lemuru* can be found to be suitable for catching based on previous research as in the graph below.

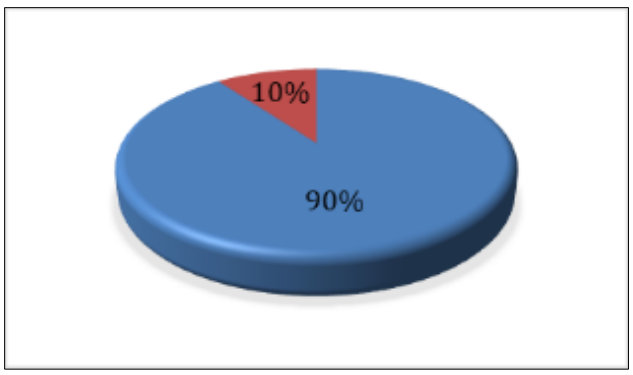

Figure 5 Percentage of Sampling Results

Based on the graph data above, it was found that 199 or 90% of the 221 fish samplings had not met the suitable catch size (LM) and 22 or 10% had reached the suitable catch size, these results are no different from previous research conducted at Coastal Fishing Port (PPP) Muncar in 2020 with the results of an average fish size length of 120 - 149 mm FL, at this size the fish have not experienced gonad maturity or all samples obtained are still small or not yet adult size.

3.4. Resource Potential (MSY)

3.4.1. Catch Per Unit Effort (CPUE)

Data on *Sardinella lemuru* catches in the Bali Strait for the period 2014-2023. By knowing the data on the number of Fishing Gear and how many trips are made each year as well as the amount of *Sardinella lemuru* production [28], the CPUE value can be calculated which can be seen in Table 2 as follows

Table 2 PPN Pengambengan Production Data

Year	Effort/trip (X)	Catch (Y) (Ton)	CPUE (Y)
2014	6,301	14,146	2.24
2015	2,956	16,038	5.42
2016	3,142	7,150	2.27
2017	2,241	77	34
2018	6,356	1,154	182
2019	7,489	16,002	2.13
2020	7,316	18,101	2.47
2021	7,202	13,747	1.90
2022	8,241	11,009	1.33
2023	4,211	8,569	2.03
Rata rata	5,546	10,599	1.91

In Table 2 above, it can be seen that the development of the amount of production from each known year, then the productivity of *Sardinella lemuru* itself has increased and decreased every year. The increase in fishing effort has an impact on decreasing the catch and profit per unit of fishing effort. However, with the status of fish resources which are public or shared resources [29]. The increase and decrease in the CPUE figures that have been known can be caused by the arrival of the *Sardinella lemuru* season itself, but the decrease in the CPUE figure from year to year results in high effort so that the catch is very high so that it is indicated that overfishing causes the following years the catch to decrease.

Table 2 above shows data on *Sardinella lemuru* fisheries at PPN Pengambengan from 2014 to 2023. This data includes three main variables each year, namely Effort/trip (X), Catch/production (Y), and CPUE. The Effort/trip variable shows the number of fishing efforts or trips carried out each year, while the Catch/production variable shows the amount of catch or production in tons. The CPUE variable reflects the efficiency of fishing effort, calculated based on the amount of catch per unit of effort.

During the period, the amount of fishing effort varied with an average of 5,546 trips per year. The highest catch occurred in 2015 with 16,038 tons, while the lowest catch occurred in 2017 with only 77 tons. The CPUE value also showed fluctuations, with the highest value of 5,426 in 2015 and the lowest value of 34 in 2017. Overall, the average annual production was 10,599 tons, and the average CPUE was 1,911.

These data provide an overview of the *Sardinella lemuru* fishery in the Bali Strait. Fluctuations in catch and CPUE can be influenced by various factors, including environmental conditions, fisheries management policies, and changes in fishing effort. An in-depth study of these data can help in formulating more effective management strategies to ensure the sustainability of *Sardinella lemuru* stocks in the Bali Strait.

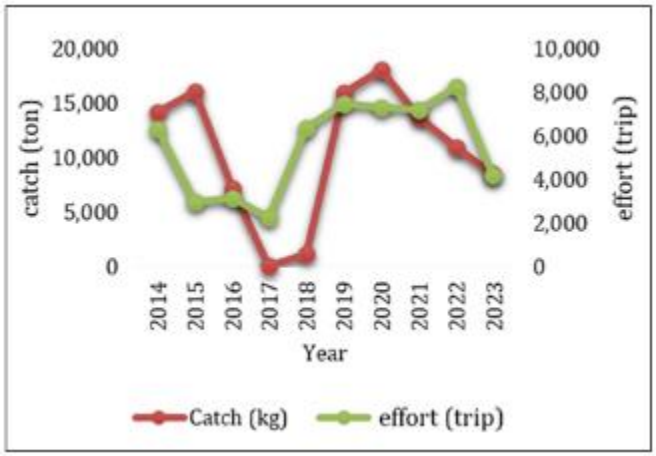

Figure 6 Catch and Effort Graph

The drastic decline in the number of catches in 2017 which only reached 77 tons compared to previous years which averaged millions of kilograms indicates a significant anomaly in the *Sardinella lemuru* fishing activity in PPN Pengambengan. Based on interviews with PPN Pengambengan and local fishermen, they said that in that year there was a lean season influenced by natural time and fishing season, this is in line with the results of previous research at the same location in the same year as Nugraha in [30] the smallest CPUE value was recorded in 2017, which was 0.034137 tons/trip with a total catch of only 77 tons and a fishing effort (effort) of 2241 trips. The small CPUE value in 2017 was because during that year the Bali Strait waters were experiencing a lean fish catch.

3.4.2. CPUE Trend

The increasing trend in CPUE provides an illustration that the level of exploitation of fish resources is still at the developing stage. CPUE with a horizontal trend is an indication that the level of exploitation of fish resources is approaching saturation of efforts, while CPUE with a decreasing trend is an indication that the level of exploitation of fish resources if left unchecked will lead to a condition called overfishing [31]. The CPUE value is one indicator of the health of fishery resources in a waters.

A CPUE value that tends to increase indicates that the fishery resources in the waters are still healthy and can be further developed. A horizontal CPUE value indicates that the fishery resources in the waters are approaching a saturation limit point, which means that the Catch Effort is at an optimal level. Meanwhile, a CPUE value that tends to decrease indicates that the fishery resources in the waters have passed the Catch Effort point [32].

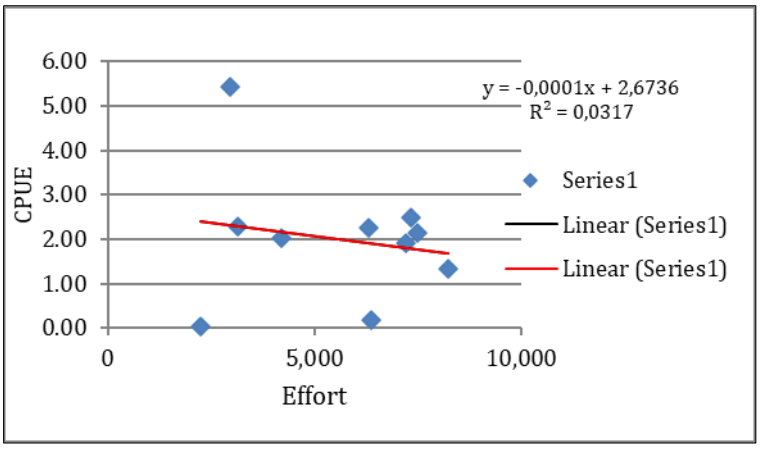

Figure 7 CPUE Trend Graph

The CPUE trend above shows Based on the image, it can be seen that the graph of the relationship between effort and CPUE produces a linear equation CPUE = -0.0001x + 2.6736 with R2 = 0.0317. The equation shows that the graph shows a decreasing CPUE trend along with the addition of effort value each year, this indicates that the level of fishing effort is getting higher. The results of the analysis produce a linear equation y = -0.0001x + 2.6736. This shows that the constant

(a) of 2.6736 states that if there is no effort, then the potential for Lemuru Fish (*Sardinella lemuru*) that the potential for Lemuru fish is available at 2.6736 Kg/Unit. The regression coefficient (b) of -0.0001 Kg/Unit states that the negative relationship between production and effort is that every additional 1 trip will cause a decrease in CPUE of -0.0001 Kg/Unit. Therefore, to maintain the abundance of *Sardinella lemuru* in the future, it is necessary to control fishing efforts. This data is in line with and not much different from Tanjov's (2024) research at PPN Pengambengan.

3.4.3. Maximum Sustainable Yield (MSY)

Maximum Sustainable Yield (MSY) is the peak condition of the catch produced year after year in a fishery. MSY is based on a fish population that is considered a single unit.

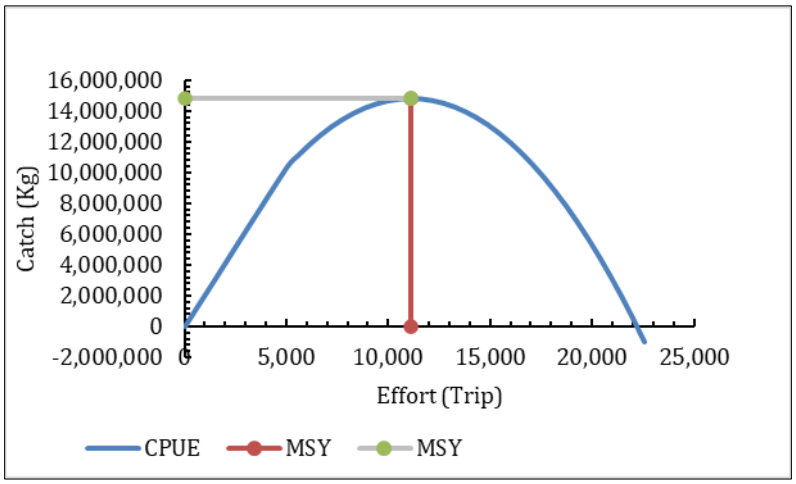

Figure 8 MSY Graph

The results of this study indicate that

- The MSY of *Sardinella lemuru* in the Bali Strait is 14,848.52 tons/year.
- The optimum effort that can be made at PPN Pengambengan is 11,115 trips/year
- The utilization rate of *Sardinella lemuru* landed at PPN Pengambengan in the last year of 2023 was 58%.

The CMSY value indicates the maximum sustainable production level, namely the highest *Sardinella lemuru* yield, while the EMSY value indicates the optimum level of effort. *Sardinella lemuru* fishing efforts that exceed EMSY can threaten the Bali Strait. The MSY graph can be used as a guideline to see whether a fishing activity has underfishing, full exploited or overfishing status [33]. Sustainable production functions to indicate the level of exploitation of *Sardinella lemuru* resources.

Based on the calculation of *Sardinella lemuru* production data in the Bali Strait waters (PPN Pengambengan) 2014-2023 as shown in Table 10. it is known that the utilization rate of lemuru production in the Bali Strait waters is 71% which means it is still below the maximum catch limit allowed, which is 14,848.52 tons/year with an average catch of 10,599 tons/year. Based on these data, the utilization status is under utilization or still below the maximum limit that can be attempted according to the maximum catch limit allowed (TAC). Thus, it can be concluded that production in the Bali Strait waters (PPN Pengambengan) 2014-2023 has not experienced overfishing, but it can be observed (Figure 3.) that the Catch Prediction curve graph will decrease if the Effort made exceeds the maximum effort limit, this is in line with research conducted by Tanjov et al., (2024) previously in PPN Pengambengan.

3.4.4. Utilization Level

According to [34] the utilization level is calculated by presenting the amount of catch in a certain year against the Total Allowable Catch (TAC) value or the amount of catch allowed at 80% of its maximum sustainable potential (CMSY) utilization level and level of effort of *Sardinella lemuru* resources in PPN Pengambengan.

Table 3 Utilization Level

Year	Actual Production	Cmsy	Emsy	Actual Effort	Utility Level (%)	JTB
2014	14,146	14,849	11,116	6,301	95	11.879
2015	16,038	14,849	11,116	2,956	108	
2016	7,150	14,849	11,116	3,142	48	
2017	77	14,849	11,116	2,241	1	
2018	1,154	14,849	11,116	6,356	8	
2019	16,002	14,849	11,116	7,489	108	
2020	18,101	14,849	11,116	7,316	122	
2021	13,747	14,849	11,116	7,202	93	
2022	11,009	14,849	11,116	8,241	74	
2023	8,569	14,849	11,116	4,211	58	
Average	10,599			5,546	71	

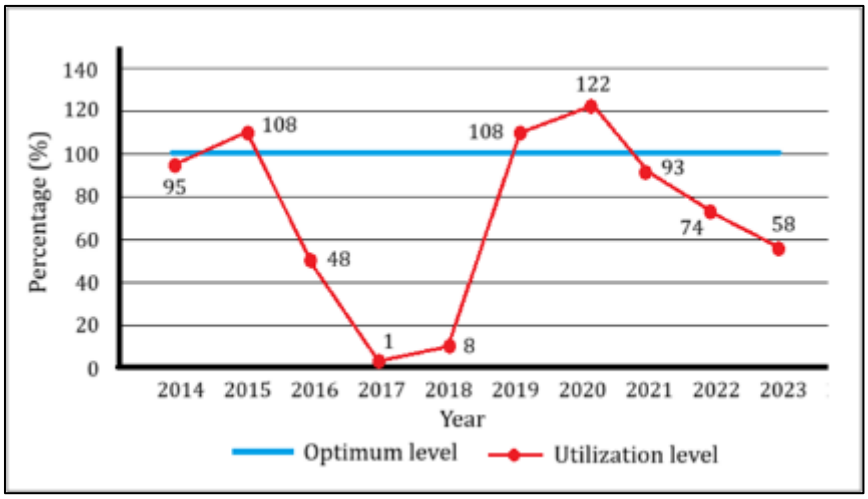

Figure 9 Graph of Utilization and Effort Levels

Based on table 3 and figure 9 above, it can be seen that the highest utilization rate of *Sardinella lemuru* resources occurred in 2020 at 122%, while the lowest utilization rate occurred in 2017 at 8%. This happened because in 2017 there was a lean season so that there was a very drastic decrease in production. This decrease also occurred at the Muncar Fishing Port in the same year, namely 2017 [35] and Tanjov et al., (2024). The utilization rate is influenced by the amount of production per year, the greater the amount of production, the greater the utilization rate. The results of the average utilization rate of *Sardinella lemuru* resources have reached optimum utilization, with an average of 71%.

Based on research conducted by Nikijuluw in [36], if based on the international agreement contained in the CCRF, then the resources that may be caught are only around 80% of the existing potential. With the increasing development of fishing efforts, there are problems with purse seines related to excess fishing capacity. Therefore, careful management is needed so that optimum productivity can be maintained sustainably [37], measurements in this analysis method cover the sustainability sector in the Bali Strait, with inconsistent results, such as several years that experienced overfishing, such as in 2014, 2015, 2019, 2020, and 2021, all of which were above 100%, with a peak in 2020 reaching 122%. After the utilization rate exceeded 100% in previous years, there was a decrease in catch in 2016, 2017, and 2018 with the utilization rate not exceeding 50%. This indicates that in those years the level of *Sardinella lemuru* resources decreased.

4. Conclusion

- The catch in this trip includes *Sardinella lemuru* 80.043 Kg, *Decapterus* spp 3.306 Kg and *Euthynnus affinis* 3.266 Kg.
- Based on the results of the measurement of the fork length of *Sardinella lemuru*, it was indicated that 90% of the majority of fish taken for size samples were still not suitable for capture according to the frequency distribution of the length of *Sardinella lemuru*, and the potential for utilization of *Sardinella lemuru* capture had an average of 71% reaching the optimum utilization level.

Compliance with ethical standards

Acknowledgments

Thanks, are especially to Mr. Jerry Hutajulu, S.Pi., M.Pi., for his knowledge and guidance while he was an Associate Professor at the Jakarta Technical University of Fisheries.

Disclosure of conflict of interest

No conflict of interest to be disclosed

References

[1] Sukojo, B. M., & Zahroh, L. (2017). Analysis of Changes in Potential Fish Areas Using Modis Level 1B Satellite Imagery (Case Study: Bali Strait). GEOID 13(1), 55-62.

[2] Listiani, A., Wijayanto, D., & Jayanto, B. B. (2017). Analysis of CPUE (Catch Per Unit Effort) and Utilization Rates of Fishery Resource Lemuru (*Sardinella lemuru*) in The Bali Strait. Indonesian Journal of Capture Fisheries 1(01), 1-9.

[3] Djamali, R. A. 2007. Evaluation of Sustainability and Optimization of Utilization of Lemuru Fish Resources (*Sardinella lemuru* Bleeker 1853) in Bali Strait Waters [Dissertation]. Bogor: Postgraduate School. Bogor Agricultural University. 185 p.

[4] Puspitarini, F. N. (2021). Level of Utilization of Lemuru Fish (*Sardinella lemuru*) Landed at the Pondokdadap Coastal Fishing Port (PPP), Sendang Biru, Malang Regency, East Java [Thesis]. Aquatic Resources Management Study Program, Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, Brawijaya University, Malang. 72 p.

[5] Nurtira, I., Restu, I. W., & Pratiwi, M. A. (2021). Production and Growth of Lemuru Fish (*Sardinella lemuru*) Landed at PPI Kedonganan, Bali. Current Trends in Aquatic Science 4(2), 141-151.

[6] Ilhamdi, H., Telussa, R. F., & Ernaningsih, D. (2016). Analysis of Utilization Level and Pelagic Fishing Season in Prigi Waters, East Java. Satya Minabahari Scientific Journal 1(2), 52–64.

[7] Jenarut, A., Pertamia, N. D., & Pratiwi, M. A. (2022). Assessment of Lemuru Fishing Technique Conditions (*Sardinella lemuru*) Based on the EAFM Approach at PPI Kedonganan, Bali. Current Trends in Aquatic Science 5(1), 48-56.

[8] Akbar, M. A., Rasyid, A., & Nelwan, A. F. P. (2023). The Level of Utilization of Small Pelagic Fish Resources in Buton Regency, Southeast Sulawesi. Torani: Journal Fisheries and Marine Science 6(2), 102-118.

[9] Simbolon, D., Wiryawan, B., Wahyuningrum, P. I., & Wahyudi, H. (2011). Utilization Level and Fishing Season Pattern of Lemuru Fish in Bali Strait Waters. PSP Bulletin 19(3), 293-307.

[10] Karundeng, C., Manginsela, F. B., Lohoo, A. V., Ferdinand F. Tilaar, F. F., Sangari, J. R. R., & Kusen, J. D. (2022). Meristic And Morphometric Characteristics of Scad Mackerel Decapterus macarellus (Cuvier, 1833). Platax Scientific Journal 10(2), 269-279.

[11] Tarigan, D. J., Cahyadi, F. D., Sasongko, A. S., Yonanto, L., & Rahayu, B. D. (2020). Potential Fishing Zones of *Rastrelligger* Sp. in Sunda Strait in Transitional Season. Journal of Fisheries and Marine Technology 11(1), 63-79.

[12] Nugraha, S. W., Ghofar, A., & Saputra, S. W. (2018). Monitoring Lemuru Fisheries in Bali Strait Waters. Management of Aquatic Resources Journal (MAQUARES), 7(1), 130–140.

[13] Dewi, D., & Husni, I. (2018). Composition of Catch Results and Catch Rate (CPUE) of Purse Seine Fishing Efforts at the Pekalongan Archipelago Fisheries Port (PPN), Central Java. JFMR-Journal of Fisheries and Marine Research 2(2), 68–74.

[14] Arsin, N., Tallo, I., & Al Ayubi, A. (2023). Types of Fish Caught by Purse Seine Fishing Gear Operated by Fishermen in Balauring Village, Omesuri District, Lembata Regency. Jurnal Bahari Papadak 4(2), 136–141.

[15] Lieonart, J. (2002). Overview Of Stock Assessment Meofods and Their Sustainability to Mediterranean Fisheries. 5th Session of SACGFCM, Rome 1-4.

[16] Gahunting, D. H., Sitanggang, E. P., & Dien, H. V. (2023). The potency of mackerel scad (*Decapterus macarellus*) caught in WPP 716 of North Sulawesi waters by Purse Seiner landed at the coastal fishing port of Tumumpa, Manado. Platax Scientific Journal 11(2), 589-602.

[17] Putra, I. N. S. A., Restu, I. W., & Ekawaty, R. (2020). Study of Lemuru Fish Stock (*Sardinella lemuru*) Landed at Muncar Coastal Fishing Port, Banyuwangi Regency, East Java Province. Current Trends in Aquatic Science 3(1), 30–38.

[18] Merta, I. G. S., & Nurhakim, S. (2017). Lemuru Fish Fishing Season (*Sardinella lemuru*, Bleeker 1853) in Bali Strait Waters. Indonesian Fisheries Research Journal 10(6):75-84.

[19] Gobel, R. F., Tamanampo, J. F. W., & Mantiri, R. (2017). Size Structure, Growth Pattern, and Condition Factors of Red Lolosi Fish (*Caesio chrysozona*, Cuvier 1830) from Totok Bay Waters, Ratatotok District, Southeast Minahasa Regency. PLATAX Scientific Journal 5(2), 162–169.

[20] Syaputra, E., Rifardi, & Nasution, S. (2016). Bioeconomic Analysis of Capture Fisheries Resources in Meranti Islands Regency, Riau Province. Journal of Fisheries and Marine Affairs 21(2), 1-8.

[21] Sparre, P., & Venema, S. C. (1998). Introduction to Tropical Fish Stock Assessment. Food and Agriculture Organization, Jakarta. Page 13

[22] Baskoro, M. D., Kushartono, E. W., & Irwani. (2019). Growth Model and Resource Status of Panulirus homarus in Cilacap, Central Java. Journal of Marine Research 8(1), 85-93.

[23] Yang, S., Zhang, Y., Zhang, H., & Fan, W. (2015). Comparison and analysis of different model algorithms for CPUE standardization in fishery. 31. 259-264.

[24] Irhamsyah, Azizah, N., & Aulia, H. (2013). Utilization Rate and Maximum Sustainable Yield of Squids in Tanah Bumbu Regency, South Kalimantan Province. PSP BULLETIN 21(2), 181-192.

[25] Wahyudi, H. (2010). Utilization Level and Seasonal Pattern of Lemuru Fish (*Sardinella lemuru*) Fishing in Bali Strait Waters. [Thesis]. Department of Fisheries Resources Utilization. Faculty of Fisheries and Marine Sciences. IPB. Bogor.

[26] Asni, A., Kasmawati, K., & Sugianto, H. T. (2022). Study of Environmental Friendliness Level of Purse Seine Fishing Gear in PPI Pontap, Palopo City. Journal of Indonesian Tropical Fisheries (JOINT-FISH) 5(2), 228–240.

[27] Wujdi, A., & Wudianto. (2015). Stock Status of Lemuru Fish Resources (*Sardinella lemuru* Bleeker, 1853) in Bali Strait Waters. Indonesian Fisheries Research Journal 21(4), 253–260.

[28] Sobari, M., Diniah, & Widiarso, D. (2018). Analysis of "Maximum Sustainable Yield" and "Maximum Economic Yield" Using Bioeconomic Static Model. Indonesian Journal of Aquatic and Fisheries Sciences 15(1), 35–41.

[29] Purwanto, & Nugroho, D. (2011). Catching Power of Purse Seine Vessels and Fishing Effort in Small Pelagic Fisheries in the Java Sea. Indonesian Fisheries Research Journal 17(1), 23–30.

[30] Tanjov, Y. E., Susilo, M. B., & Samanta, P. N. (2024). Analysis of CPUE and MSY of Lemuru (*Sardinella lemuru*) Production in Bali Strait Waters. ALBACORE Journal of Marine Fisheries Research 8(1), 089–097.

[31] Aryani, D., Awalia, R., & Susanto, A. (2024). Utilization Rate of Skipjack Tuna (*Katsuwonus pelamis*) In Binuangeun Water, Lebak Regency, Banten Province. AGRIKAN - Journal of Agribusiness Fisheries 17(1), 123–130.

[32] Kristiana, H., Malik, J., Anwar N. (2021). Estimation of the Status of Small-Scale Fisheries Resources in Semarang City. Journal of Tropical Fisheries Management 05(01), 51-58.

[33] Agustakristi E. R., & Kohar M, A. (2018). Bioeconomic Analysis of Gordon-Schaefer Model of Lobster (*Panulirus* Sp.) Fishing Resources in Gunungkidul Regency. Journal of Fisheries Resources Utilization Management and Technology, 7(4), 11–18.

[34] Arifin, Z., Wahono, B., Prihatmoko, D., & Riyoko, S. (2020). Innovation in Increasing Local Superior Fish Catch Results by Purse Seine Fishermen Using GPS Technology. JIPEMAS: Journal of Innovation Results of Community Service 3(1), 54.

[35] Nugraha, S. W., Ghofar, A., & Saputra, S. W. (2018). Monitoring Lemuru Fisheries in Bali Strait Waters. Management of Aquatic Resources Journal (MAQUARES) 7(1), 130-140.

[36] Rahman, D. R., Triarso, I., & Asriyanto. (2013). Bioeconomic Analysis of Pelagic Fish in Capture Fisheries Business at Tawang Coastal Fishing Port, Kendal Regency. Journal of Fisheries Resources Utilization Management and Technology 2(1), 1–10.

[37] Hufiadi, & Nurdin, E. (2013). Efficiency of Purse Seine Fishing in Several Watampone Fishing Areas. Indonesian Fisheries Research Journal 19(1), 39–45.