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Stock Condition and Utilization Level for Sustainability of Skipjack Tuna in Flores Sea, Bulukumba Regency

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Abstract. The fishing of skipjack tuna (*Katsuwonus pelamis*) in the Flores Sea, Bulukumba Regency is currently conducted on an open-access basis. The majority of fishermen engage in the practice of catching fish without restriction, it is therefore imperative to gain an understanding of the biological aspects of skipjack tuna, including size structure, age groups, growth, and mortality rates, in order to effectively manage this resource. The objective of this study is to evaluate the stock condition and the level of utilization of skipjack tuna resources in the Flores Sea, Bulukumba Regency, South Sulawesi. The methods employed include survey techniques, stock condition analysis, potential (MSY) analysis, and an evaluation of the utilization level of skipjack tuna resources. The results of the study indicate that the skipjack tuna population in the Flores Sea is currently undergoing full exploitation. The fishing mortality rate 0.3930 per year is considerably higher than the natural mortality rate 0.2421 per year. This indicates that the primary cause of mortality is fishing activity. Furthermore, the utilization rate has also reached full exploitation. In light of these circumstances, it is imperative that fishermen refrain from augmenting the quantity of fishing apparatus at their disposal or embarking on fishing expeditions, in order to forestall the phenomenon of overfishing.

Keywords: Stock Condition, Utilization Rate, Skipjack Tuna.

1 Introduction

The Flores Sea represents a marine area with considerable fishery resource potential, offering an invaluable alternative for meeting food needs and underscoring the necessity for optimal management. The Flores Sea is situated within the Fisheries Management Area of the Republic of Indonesia (WPP-RI 713), which is characterised by a rich biodiversity of large pelagic fish resources, including the skipjack tuna *(Katsuwonus pelamis)*. Skipjack tuna is an economically significant large pelagic species in the Flores Sea, exploited by fishermen from various districts within and outside South Sulawesi Province using a variety of fishing gear and technologies, including pole and line (huhate), hand lines, trolling lines, purse seine nets, and occasionally surface gill nets, with the aid of fish aggregating devices or by targeting schools of fish [1].

While skipjack tuna is a renewable resource, its recovery rate may not always align with the rate of exploitation. It thus falls upon the government to establish policies for the stewardship of Indonesia's fishery resources, with a view to ensuring their

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sustainability and conservation for the benefit of the entire community. Presently, fishing activities in the Flores Sea are conducted on an open-access basis. This allows all fishermen in coastal districts or cities to fish freely. The fishermen typically engage in fishing activities at their discretion, guided by their accumulated experience. To effectively manage skipjack tuna resources, it is imperative to obtain data on their population biology, including size structure, age groups, growth patterns, and mortality rates specific to the fishing areas in question.

The objective of this study is to evaluate stock condition and utilization level of skipjack tuna (*Katsuwonus pelamis*) in the Flores Sea, Bulukumba Regency, South Sulawesi. The findings will provide data for local government authorities, particularly the Marine and Fisheries Office, to inform the management and utilization of skipjack tuna and to support the sustainability of skipjack tuna in the Flores sea region.

2 Literatur Review

The skipjack tuna *(Katsuwonus pelamis)* is one of the most economically significant fish species found in Indonesian waters. This fish is highly esteemed for its palatability and flavorful meat. As a constituent of the tuna resources, the skipjack tuna represents a significant source of animal protein for the local community. Skipjack Tuna is a significant pelagic fish resource frequently targeted in commercial fishing operations, both in Indonesia and other countries [2].

2.1 Age Groups

A fundamental understanding of the age composition of fish populations or communities within a specific water body is of paramount importance, particularly when linked to production. This is intimately connected to the administration of fish as a biological asset of the surrounding environment. By understanding the age of the fish and the composition of the surviving individuals, one can assess the success or failure of fish reproduction in a specific year [3].The success and future of a fish stock depend on the addition of new individuals and the age class composition of the fish that are targeted by fishing. Knowledge of these aspects can serve as a foundation for taking management actions for fish stocks [4].

In general, the age of a fish can be determined by examining annual marks on various parts of the fish's body, including scales, otoliths, fins, and operculum bones. These marks are the result of fluctuations in metabolic rate, with a slowing of metabolism during certain periods and an acceleration of metabolism at other times. However, this method is primarily applicable in regions with four distinct seasons, where growth rates exhibit a seasonal pattern, with a slowing down during winter and an acceleration during summer. In tropical regions like Indonesia, the temperature difference between the rainy and dry seasons is generally low, so it does not significantly affect fish growth and cannot be used as an age determination indicator [3].

Reported that Skipjack Tuna captured in the Makassar Strait consists of three age groups [5]. Skipjack Tuna captured in the Barru area of the Makassar Strait consists of three age groups [6]. Skipjack Tuna captured in the Bulukumba area consists of three age groups [7].

2.2 Growth

Growth can be defined as the increase in length or weight of a fish over a certain period. Growth in an individual refers to the increase in tissue due to cell division through mitosis, which occurs when there is an excess of energy and amino acids (proteins) obtained from food. In contrast, growth in a population refers to an increase in numbers [3]. The growth of an organism is influenced by a number of factors, both internal and external. Internal factors, which are typically challenging to regulate, encompass heredity, sex, age, disease, and parasites. External factors that typically affect fish growth include food availability and water temperature. Nevertheless, it remains unclear which of these factors exerts the greatest influence. Food availability is influenced by water quality parameters such as dissolved oxygen, carbon dioxide, hydrogen sulfide, salinity, and alkalinity [8].

Fish with a high growth rate coefficient (K) reach their asymptotic length in a shorter time, whereas fish with a low growth rate require a longer time to reach their asymptotic length and tend to have a longer lifespan [8]. The growth in length of fish varies with age; young fish experience relatively rapid growth, while mature fish grow more slowly and eventually cease growing upon reaching their asymptotic length [9]. The growth rate of Skipjack Tuna in the Flores Sea is $K = 0.49$ per year [5]. The growth rate of Skipjack Tuna in the Bone Bay is $K = 0.25$ per year [10]. The growth rate of Skipjack Tuna in the Barru area of the Makassar Strait is $K = 0.41$ per year [6].

2.3 Mortality

Mortality is defined as the number of individuals lost over a specified period. In the context of fisheries, mortality can be classified into two primary categories: natural mortality (M), which encompasses the loss of individuals due to factors such as old age, cannibalism, and predation; and fishing mortality (F), which pertains to the loss of individuals resulting from human fishing activities. A high natural mortality rate is observed in fish with a high growth rate coefficient (K), while a low natural mortality rate is observed in fish with a low growth rate coefficient (K).

Fish with high mortality rates tend to have short life cycles, little age variation within the population, and relatively rapid stock turnover, resulting in higher production potential [9].

Total mortality of fish in the wild is defined as the exponential rate of decrease in fish abundance over time. Total mortality can be expressed by the equation $Z = F + M$, where F represents fishing mortality and M represents natural mortality [4].The exploitation rate indicates the level of fishing pressure on a stock. A fish stock is at its maximum sustainable production level if the exploitation rate is at its maximum and sustainable, which occurs when $F = M$, or when the exploitation rate is equal to 0.5, indicating that the fish stock is under maximum exploitation [11].

2.4 Yield per Requitment

Yield can be defined as the portion of a population that can be harvested by humans, while Recruitment refers to the addition of new members into a population. In fisheries terms, recruitment means the addition of new, exploitable individuals into an existing stock that is already being fished. This new supply results from reproduction and has reached a stage in its life cycle where it is large enough to be caught by the fishing gear used [3].

Yield per Recruitment (Y/R) is a model commonly used as a basis for fisheries management strategies, alongside production models and surplus production models. The Y/R model is more straightforward and practical because it requires fewer input parameters compared to other Y/R models. Yield per Recruitment (Y/R) is a model frequently used as a basis for fisheries management strategies because it provides insights into the short-term and long-term effects of different management different actions [11].

2.5 Utilization Level

The minimum legal size for Skipjack Tuna in Bone Bay is > 55 cm Fork Length (FL) for females and > 60 cm FL for males [13] [14] [15]. The minimum legal size for Skipjack Tuna in the Flores Sea is > 55 cm FL for females and > 60 cm FL for males. Furthermore, it is noted that the majority of Skipjack Tuna captured by fishermen using purse seines without fish aggregating devices (FAD), purse seines with FAD, and surface gill nets are below the legal size [15].

2.6 Stock Condition

As reported by the Department of Marine Affairs and Fisheries of Bulukumba Regency, the annual catch production of skipjack tuna in the Flores Sea has demonstrated considerable variability from year to year, with a recent decline in catch levels. The catch of skipjack tuna exhibited an upward trajectory from 2006 to 2014, followed by a decline in subsequent years. In 2006, the production of skipjack tuna was 1,050.3 tons per year, rising to 6,465.9 tons in 2014, and then decreasing to 4,114.5 tons in 2015.

Fishermen in Bulukumba Regency operate in two distinct areas: the western part of the Flores Sea, encompassing the Selayar Islands, and the eastern part of the Flores Sea, also surrounding the Selayar Islands. During the seasonal transitions from west to east (March–April), east to west (September–October), and east to west (May–August), local fishermen engage in skipjack tuna fishing in coastal waters (approximately 0.5 to 4 miles) and offshore (in the eastern portion of the Flores Sea around the Selayar Islands) using fish aggregating devices (FADs).

Additionally, fishermen engage in fishing activities near the coast (approximately 0.5 to 4 miles) and offshore (in the western region of the Flores Sea around the Selayar Islands) through the utilization of non-FAD techniques. During the west season (November–February), fishermen predominantly employ fish aggregating devices (FADs) for fishing activities in the eastern portion of the Flores Sea, in proximity to the Se-layar Islands, at distances of approximately 0.5 to 4 miles from the coast. However, some fishermen in Bulukumba Regency also engage in fishing activities near the coast (approximately 0.5 to 4 miles) in the western part of the Flores Sea around the Selayar Islands using non-FAD methods during the west season (November to February).

3 Research Method

This study employs a survey method to collect both primary and secondary data. This is achieved through direct observation and interviews with fishermen, fishing industry operators, and policymakers. The objective is to evaluate the technical, economic, and social aspects associated with skipjack tuna fishing. The research was conducted over a period of three months, from October to December 2016, in Tanah Beru Village, Bonto Bahari District, Bulukumba Regency, South Sulawesi, which serves as the fishing base.

The data analysis methods employed included stock condition analysis, size structure analysis using column diagrams, age group analysis using the Bhattacharya method [8], growth analysis according to the Ford-Walford and Von Bertalanfy method [16], and natural mortality analysis with Pauly's empirical formula [16]. Fishing mortality, total mortality and yield per recruitment (Y/R) is calculated using Beverton and Holt's formula [8], while the legal size is determined through Mallawa's equation [12]. The stock condition is assessed using Mallawa's equation [15], and the MSY potential is evaluated through the Surplus Production Model from Schaefer or Fox [12]. Finally, the utilization level is determined through Mallawa's equation [12].

4 Result

4.1 Overview

Fishermen in Bulukumba Regency operate in two distinct areas: the western part of the Flores Sea around the Selayar Islands and the eastern part of the Flores Sea around the Selayar Islands. During the seasonal transitions from west to east (March–April), east to west (September–October), and east to west (May–August), local fishermen engage in skipjack tuna fishing in coastal areas situated between 0.5 and 4 miles offshore. This occurs in both the eastern and western parts of the Flores Sea, with the use of fish aggregating devices (FADs). Additionally, they engage in fishing activities in coastal areas (0.5 to 4 miles) and offshore in the western part of the Flores Sea around the Selayar Islands, employing non-FAD techniques.

During the west season (November–February), fishermen in Bulukumba Regency predominantly employ fish aggregating devices (FADs) for fishing in coastal areas (0.5 to 4 miles) in the eastern part of the Flores Sea around the Selayar Islands. However, some fishermen also employ non-FAD methods during the west season in coastal areas (0.5 to 4 miles) in the western part of the Flores Sea around the Selayar Islands.

The fishermen in Bulukumba employ a range of fishing technologies, including purse seine and gill nets. The fishermen typically engage in fishing activities in two distinct types of areas: non-FAD and FAD areas. In the absence of FADs, fishers rely on natural indicators to locate schools of fish. These include the presence of seabirds diving into the water or visible surface disturbances created by fish schools. Fishing in areas where floating aquaculture devices (FADs) have been deployed necessitates a visit to the relevant pre-installed FAD. The purse seine gear utilized in the study is employed in the Flores Sea, with Tanah Beru Village in Bonto Bahari District, Bulukumba Regency serving as the fishing base for the research.

4.2 Stock Condition

Age Group.

The research findings indicate that a total of 1,782 skipjack tuna were measured at the landing site, with a size range from 250 mm to 640 mm. The largest frequency of lengths was observed in the size class of 334–345 mm, with 126 individuals, representing the most common size range among the catch. In contrast, the lowest frequency was observed in the size class of 635–646 mm, with only six individuals.

Fig. 1. Frequency of Catch and Theoretical (FC) of Skipjack Tuna in the Flores Sea Waters, Bulukumba Regency.

The Bhattacharya method and the natural logarithm of theoretical frequency differences, mapped against the midpoint values, were employed in the analysis, which identified three relative age groups of skipjack tuna. The mean length of fish in the I age group was 327 mm, in the II group it was 456 mm, and in the III group it was 550 mm.

In the Flores Sea, during the transition season from east to west, Skipjack Tuna had two age groups with average fork lengths of 31.36 cm for age group I and 49.12 cm for age group II [17]. The skipjack fish caught with pole and line in the waters of Bone Bay exhibited three distinct age groups, with an average length of 26.10 cm for group I, 53.51 cm for group II, and 74.94 cm for group III [10]. The discrepancies in the number of age groups and the mean length of individuals in the catch are markedly affected by the selectivity of fishing gear and the prevailing local aquatic conditions [15].

Table 1. The relationship between the average length range of each age group and the relative length of Skipjack Tuna

Relative Age (years)	Range Length (mm)	Averange Length of Each Age Group (mm)
I	250 – 393	327
II	394 – 478	456
III	479 - 646	550

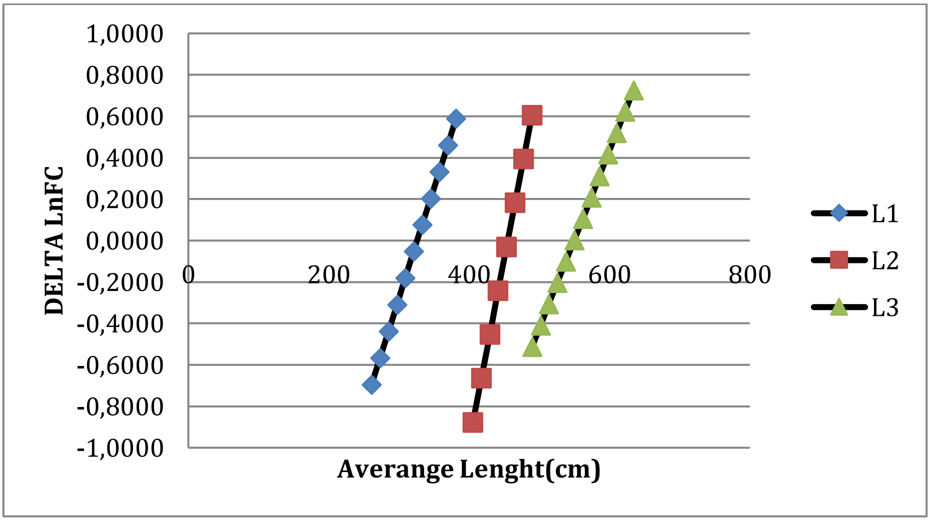

Fig. 2. The relationship between the average length range of each age group and the relative length of Skipjack Tuna

The research findings were plotted on a logarithmic scale of total length against midpoint values, which revealed three average lengths for each age group of skipjack tuna: 327 mm, 456 mm, and 550 mm. The correlation between these length ranges and relative age suggests that the mean length of fish increases with age.

Growth.

Using the Ford-Walford method [16], the asymptotic length ($L\infty$) of Skipjack Tuna captured in the Flores Sea, Bulukumba Regency, is found to be 803.39 mm, with a growth rate (K) of approximately 0.315 per year. The value for t0, obtained using the Pauly equation with the parameters for asymptotic length ($L\infty$) and growth coefficient (K), t0 is -0.6720 years. Based on these values for K, $L\infty$, and t0, the growth equation for Skipjack Tuna using the Von Bertalanffy model [16] is given by:

$$Lt=803(1-e-0.31(t-(-0.672))) \quad (1)$$

Based on the growth equation, it is possible to determine the length of Skipjack Tuna at various relative ages, allowing for the calculation of annual growth increments until reaching asymptotic length. The study results indicate that Skipjack Tuna in the Flores Sea exhibit a low growth rate (K), as it is below 0.5 per year, with a value of 0.31 per year. Consequently, with an asymptotic length ($L\infty$) of 803.39 mm, the tuna require a considerable amount of time to reach their maximum size.

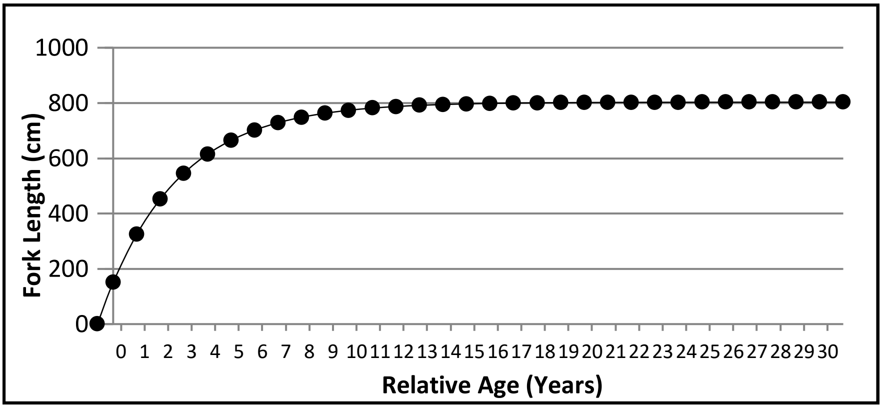

Fig. 3. Growth curve of skipjack tuna in the waters of the Flores Sea, Bulukumba Regency.

Mortality.

Total mortality rate (Z) of 0.6352 per year, estimated using the Beverton and Holt method. The natural mortality rate (M) was determined to be 0.2421 per year using Pauly's empirical formula, incorporating a growth coefficient K = 0.32 per year, an asymptotic length $L\infty$ = 803.40 mm, and a temperature T = 30°C. The fishing mortality rate (F) was calculated by subtracting natural mortality (M) from total mortality (Z), resulting in F=0.3930 per year. The exploitation rate (E) was then derived by dividing F by Z, giving an estimated E=0.61 per year.

Table 2. The relationship between the average length range of each age group and the relative length of Skipjack Tuna

Population parameters	Estimated Value (per year)
Total Mortality (Z)	0.6352
Natural Mortality (M)	0.2421
Fishing Mortality (F)	0.3930
Exploitation Rate (E)	0.6188

A comparison between natural mortality (M) and fishing mortality (F) indicates that the Flores Sea is currently experiencing a considerable degree of fishing pressure, which may ultimately result in a decline in fish stocks, particularly in the case of the skipjack tuna *(Katsuwonus pelamis).* The fishing mortality rate 0.3930 per year is notably higher than the natural mortality rate 0.2421 per year. This indicates that the primary cause of mortality for skipjack tuna in the Flores Sea, Bulukumba Regency, is fishing activities. Furthermore, the absence of restrictions on operational areas and the lack of regulations concerning the minimum size of fish allowed for capture serve to exacerbate the situation.

Exploitation Rate and Yield per Recruit.

The exploitation rate (E) is defined as the proportion of total mortality (Z) that can be attributed to fishing (F). The estimated exploitation rate (E) for skipjack tuna in the Flores Sea is 0.6188 per year, calculated by dividing the fishing mortality rate (F) by the total mortality rate (Z). This value indicates that the Flores Sea is currently experiencing overfishing, as the exploitation rate (E) exceeds the optimal level.

The yield per recruitment (Y/R) is a model that provides insights into fisheries management strategies [11]. It measures the yield obtained from the population per unit of new recruitment. The optimal yield per recruitment (Y/R) value derived from the research is 0.1061 grams per recruitment, with an exploitation rate of 0.60. This indicates that at the present level of fishing pressure, the yield per recruitment is suboptimal, suggesting the possibility of overfishing and the necessity for management interventions to guarantee sustainable fishing practices and enhance stock health.

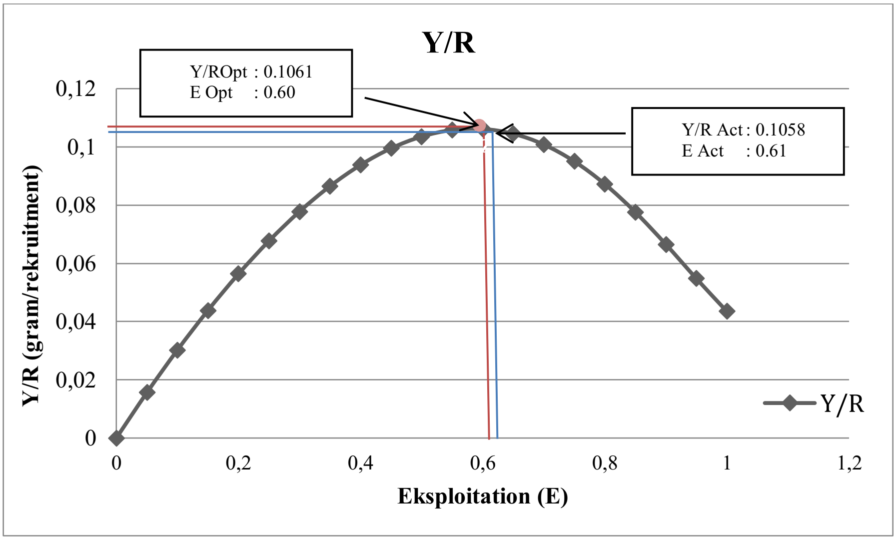

Fig. 4. Yield per Recruitment (Y/R) relationship curve to the Exploitation Rate Value (E) of Skipjack tuna in the Flores Sea, Bulukumba Regency.

The estimated yield per recruitment (Y/R) for the Flores Sea in Bulukumba was calculated using the Beverton-Holt method [17], resulting in a value of 0.1058 per recruitment. This suggests that the current Y/R value is approaching the optimal level, indicating that the fishery may be approaching a point where further increases in exploitation could have a detrimental impact.

The research findings show that when the exploitation rate ranges from 0 to 0.60, the Y/R increases, reaching an optimal point at E = 0.60. However, when the exploitation rate exceeds 0.60, the Y/R begins to decline, as indicated by the downward shift on the curve. This trend indicates that the current exploitation rate is higher than the optimal E, suggesting that the skipjack tuna fishery in the Flores Sea, Bulukumba is over exploited, surpassing the optimal level and potentially leading to unsustainable fishing practices.

Percentage of Legal Size Fish.

Based on the analysis of tuna catches using purse seine and gill net methods with Mallawa's criteria, it was found that the legal size for skipjack tuna is greater than 55 cm. The percentage of legal-sized skipjack tuna in the waters of Flores is 25% [19]. In the waters of Flores, the proportion of legal-sized tuna in non-rumpon areas is 28% (280 fish), while 72% (705 fish) are below the legal size. In rumpon areas, there were no legal-sized fish (1,306 fish) [17].

Table 3. Stock Condition Indicator Values for Skipjack Tuna in the Flores Sea Bulukumba Regency

Criteria	Result	Information
Skipjack Size Structure		
Length rate	25 – 64 cm	
Dominant size	33,4 – 34,5 cm	Population dominated by young and pre adult fish
Averange length	48,2 cm	
Age Group	3 cohort	Fish leaving the Flores Sea to move toward spawning area
Fishing mortality rate (F)	0,3930	Low
Exploration Rate (E)	0,6188	Normal
Population Growth Rate (K)	0,32	Normal
Yield per Reqruitment		
Y/R actual	0,1058	Aproaching the optimal value
Y/R optimum	0,1016	
Percentage of legal size fish	22,6%	Very low

Table 4. Calculation of the Stock Condition of Skipjack Tuna in the Flores Sea Bulukumba Regency

Criteria	Number	Value	Number x Value
Size structure			
1. <20 % of Catchable Fish		1	
2. ≥ 20 – 50 % of Catchable Fish	2,0	**(3)**	6,0
3. > 50 % of Catchable Fish		5	
Numbers Age Groups			
1. One Age Groups		1	
2. Two Age Group	1,5	3	7,5
3. ≥ Three Age Groups		**(5)**	
Fishing mortality rates			
1. F Value > 2,0		1	
2. F Value 1,0 – 2,0	1,5	3	7,5
3. F Value < 1,0		**(5)**	

Explotation Rate			
1. E Value > 0,75		1	
2. E Value 0,50 – 0,75	1,00	**(3)**	3,0
3. E Value < 0,5		5	
Population Growth (K)			
1. K < 0,30 per year		1	
2. K 0,30 – 0,50 per year	1,00	**(3)**	3,0
3. K > 0,50 per year		5	
Yield per Reqruitment			
1. Y/R actual, > Y/R optimal		1	
2. Y/R actual = Y/R optimal	1,00	3	5,0
3. Y/R actual < Y/R optimal		**(5)**	
Catchable Fish Percentage			
1. < 20 % Catchable Fish		1	
2. 20 – 50 % Catchable Fish	2,00	**(3)**	6,0
3. > 50 % Catchable Fish		5	
Total	10,00		38
Stock Condition			76%

Based on the research results using Mallawa method [15], it can be concluded that the stock of skipjack tuna in the Flores Sea is classified as good condition, as the percentage of suitable fish obtained is 76%.

Analysis of Potential (MSY) and Utilization Rate of Skipjack Tuna Resources.

Analysis of Skipjack Tuna Resource Potential in Bulukumba Regency.

In the Flores Sea, specifically in the WPP 713 area, particularly in Bulukumba Regency, Bonto Bahari District, and Tanah Beru Village, fishermen catch skipjack tuna using purse seine and gill net. The production, fishing effort, and trips for skipjack tuna in Bulukumba Regency for the given year are as follows.

Table 5. Catch Production and Unit Effort using the Schaefer method and the fox methode

Year	Catch Production (ton)	Unit Effort	CPUE Schafer	CPUE Fox	Unit
2011	3667.4	268	13.6816	2.6161	
2012	5400.2	180	29.8546	3.3963	
2013	6465.9	179	36.1001	3.5863	
2014	6464.9	161	39.9518	3.6877	
2015	4114.5	241	17.0726	2.8375	
	Intercep (a)		78.0751	5.3356	
	slope (b)		-0.2461	-0.0102	
MSY (last 5 years)			**6.191,85**	**7.459**	**Ton**
Fmsy (Effort in Last 5 years)			**158.6129**	**97.674**	**Trip**

Other results regarding the relationship between catch per trip (C/f) and fishing effort (f) suggest that the values of a (intercept) and b (slope) can be estimated using the Schaefer and Fox exponential equations, as illustrated in the figure. Based on the values of a and b, the Maximum Sustainable Yield (MSY) for Skipjack Tuna in the Flores Sea, Bulukumba Regency, is 6.191.85 tons per year using the Schaefer method and 7.459 tons per year using the Fox method.

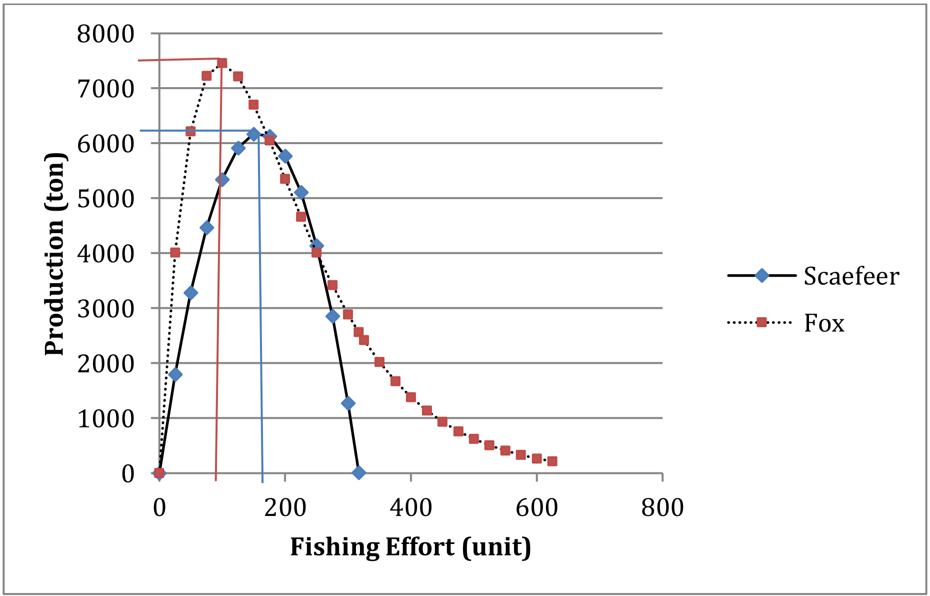

Fig. 5. Relationship between the catch production and unit efforts of the Schaefer method and the fox methode

According to the Schaefer model, the optimal fishing effort (FOptimum) 158 trips, which is the maximum effort to achieve the Maximum Sustainable Yield (MSY). If the effort is continuously increased beyond this optimal level, the catch will decline. This means that with efforts exceeding 158 trips, the fishing operations will become economically unviable as the operational costs increase while the catch decreases, failing to cover the costs of the operation. On the other hand, the Fox model indicates that the maximum effort to achieve MSY is 97 trips. If the fishing effort or the number of trips exceeds this optimal value, the catch will decrease, leading to financial losses in the fishing operations.

4.3 Level of Utilization of Skipjact Tuna Resources in Bulukumba Regency

The lowest CPUE value was recorded in 2011 at 13.68 kg/unit, while the highest was in 2014 at 39.95 kg/unit. Calculations using the Schaefer model yielded values of a=78.075 and b=−0.246, resulting in a Maximum Sustainable Yield (MSY) of 6.191,85 tons. In contrast, calculations using the Fox model provided values of a=5.3356 and b=−0.0102, resulting in an MSY of 7.459 tons.

Table 6. Utilization Rate of Skipjack Tuna in Bulukumba Regency from 2011 to 2015

Years	Utilization Rate (%) Schafer	Utilization Rate (%) Fox
2011	113,05	102,51
2012	88,97	91,67
2013	106,20	108,81
2014	104,45	100.88
2015	91	96.97
Average	**100,73%**	**100,16%**

The utilization rate of tuna in Bulukumba Regency, based on data over five years, is categorized as follows: if the utilization rate exceeds 100%, it is considered "fully exploited." According to the Schaefer model, over exploitation is observed in the years 2011, 2013, and 2014, with utilization rates of 113.05%, 106.20%, and 104.45%, respectively. In contrast, the years 2012 and 2015 had utilization rates below 100%. The average utilization rate is 100.73%, indicating that the resource is in a "fully exploited" state. Similarly, using the Fox model, over exploitation is evident in the years 2011, 2013, and 2014, with utilization rates of 102.51%, 108.81%, and 100.88%, respectively. The years 2012 and 2015 had utilization rates below 100%, with an average rate of 100.16%. This also indicates that the resource is "fully exploited."

5 Conclusion

The research conducted on skipjack tuna *(Katsuwonus pelamis)* populations at landing sites in the Flores Sea, Bulukumba Regency, involved the measurement of 1,782 individual fish. The length of the measured fish ranged from 250 mm to 640 mm, and the population was categorized into three distinct age groups. The growth rate coefficient (K) for the skipjack tuna was found to be 0.31 per year, which is below the typical growth rate. This lower growth rate suggests that skipjack tuna in this region require a relatively longer period to attain their maximum size. The estimated asymptotic length ($L\infty$), which represents the theoretical maximum size a fish can reach, was calculated to be 803.39 mm.

The study also examined mortality rates among the skipjack tuna population. Natural mortality (M) was estimated at 0.2421, Fishing mortality (F) was higher, recorded at 0.3930, showing the significant impact of fishing activities. The total mortality rate (Z), which is the sum of both natural and fishing mortality, was 0.6352, with the exploitation rate (E) calculated at 0.6188. higher than optimal exploration rate which is 0.60, indicates that the fish population is being subjected to considerable fishing pressure, which, if left unchecked, could lead to overfishing.

The yield per recruit (Y/R) analysis, which measures the expected yield or biomass produced by each recruit during its lifetime, yielded a value of 0.1058 grams per recruit. This is close to the estimated optimal Y/R value of 0.1061 grams per recruit, indicating that the current exploitation of the stock is nearing its optimal level of productivity.

The stock condition score was found to be 76%, indicating that the population remains in a relatively favorable condition despite the high exploitation rate.

Nevertheless, resource utilization assessments based on the Schaefer and Fox surplus production models classify the skipjack tuna stock in the Flores Sea as "fully exploited". This classification suggests that the current fishing pressure is at the maximum level, and any further increase in fishing effort could lead to overexploitation. It is necessary to implement sustainable management measures to ensure the long-term health of fisheries. The main strategy includes regulating and limiting the number of fishing gear used, This is very important to maintain a balance between economic utilization and conservation of skipjack fish stocks *(Katsuwonus pelamis)* in the Flores Sea, Bulukumba Regency for long-term sustainability.

References

1. M. Yahya, Pemanfaatan Sumber Daya Tuna Dan Cakalang Secara Terpadu . Bogor, Indonesia: IPB, 2001.
2. S. Gigentika, "Optimasi Pengembangan Perikanan Cakalang di Kabupaten Lombok Timur Provinsi Nusa Tenggara Barat," Tesis, Sekolah Pascasarjana Institut Pertanian Bogor, Bogor, 2012.
3. M. Effendie, Biologi Perikanan . Yogyakarta, Indonesia: Yayasan Pustaka Nusatama, 1997, pp. 92-105.
4. E. R. Biusing, "Dinamika Populasi Dan Aspek Biologi Reproduksi Stok Ikan Kembung Lelaki (Rastrelliger kanagurta cuvier, 1987) Di Sekitar Perairan Laut Pantai Timur Selatan Negeri Sabah Kesatuan Negara Malaysia," Karya Ilmiah, Jurusan Manajemen Sumberdaya Perairan Fakultas Perikanan Institut Pertanian Bogor, Bogor, 1987.
5. F. Samad, "Studi Beberapa Parameter Dinamika Populasi Ikan Cakalang di Perairan Laut Flores," Makassar, 2002.
6. A. Andriani, "Studi beberapa Parameter Dinamika Populasi dan Tingkat Eksploitasi Ikan Cakalang (Katsuwonus pelamis) di Perairan Barru, Sulawesi Selatan," Skripsi, Fakultas Ilmu Kelautan dan Perikanan, Universitas Hasanuddin, Makassar, 2012.
7. M. Fidyatul, "Studi beberapa Parameter Dinamika Populasi Ikan Cakalang (Katsuwonus pelamis) di Perairan Bulukumba, Sulawesi Selatan," Skripsi, Fakultas Ilmu Kelautan dan Perikanan, Universitas Hasanuddin, Makassar, 2013.
8. P. Sparre, E. Ursin, and S. C. Venema, Introduction to Tropical Fish Stock Assessment. Part I-manual . Rome: Food and Agriculture Organization of the United Nations, 1989.
9. G. V. Nikolsky, The Ecology of Fisheries . New York: Academic Press, 1963.
10. S. F. Rezkika, "Pendugaan Beberapa Parameter Dinamika Populasi Ikan Cakalang (Katsuwonus pelamis) di Perairan Teluk Bone, Kabupaten Luwu Sulawesi Selatan," Skripsi, Fakultas Ilmu Kelautan dan Perikanan, Universitas Hasanuddin, Makassar, 2011.
11. J. A. Gulland, Fish Stock Assessment. A Manual of Basic Methods . New York: John Wiley and Sons Inc., 1983.
12. A. Mallawa, Musbir, F. Amir, and A. A. Marimba, "Analisis Struktur Ukuran Ikan Cakalang (Katsuwonus pelamis) Menurut Musim, Daerah dan Teknologi Penangkapan Ikan di Perairan Luwu Teluk Bone, Sulawesi Selatan," J. Sains dan Teknologi Balik Diwa , vol. 3, no. 2, pp. 29–38, 2012.
13. H. Baso, "Kajian Biologi Populasi Ikan Cakalang (Katsuwonus pelamis) di Perairan Luwu Teluk Bone," Tesis, Program Pascasarjana Universitas Hasanuddin, Makassar, 2013.
14. R. Alamsyah, "Kajian biologi populasi ikan cakalang (Katsuwonus pelamis) secara temporal di perairan Teluk Bone," Program Pascasarjana Universitas Hasanuddin, Makassar, 2013.
15. A. Mallawa, Faisal, A., and M. Zainuddin, "Biologi populasi dan aspek perikanan ikan cakalang (Katsuwonus pelamis) di perairan Laut Flores," Laporan Penelitian BOPTN Berbasis Laboratorium, PS Pemanfaatan SDP, FIKP UnHas, Makassar, 2013.

16. P. Sparre and S. C. Venema, Introduksi Pengkajian Stok Ikan Tropis . Jakarta: Pusat Penelitian dan Pengembangan Perikanan, Badan Penelitian dan Pengembangan Pertanian, 1999.
17. W. Susaniati, "Kajian Biologi Populasi Ikan Cakalang Katsuwonus pelamis di Perairan Laut Flores, Sulawesi Selatan," Tesis, Fakultas Ilmu Kelautan dan Perikanan, Universitas Hasanuddin, Makassar, 2014.
18. D. Pauly, "Some Simple Methods for the Assessment of Tropical Fish Stock," FAO Fish. Tech. Pap. , vol. 234, p. 47, 1983.
19. A. Mallawa, F. Amir, and W. Susanti, "Struktur ukuran dan pertumbuhan populasi ikan cakalang (Katsuwonus pelamis) di Perairan Laut Flores Sulawesi Selatan," in Prosiding Seminar Nasional , Universitas Hasanuddin, Makassar, 2014.