# Population Dynamic of Mackerel Scad (*Decapterus macarellus* Cuvier, 1833) in the Timor Sea

**Susy Herwaty[1]*, Achmar Mallawa[2], Najamuddin[2], Mukti Zainuddin[2]**

[1]Faculty of Fisheries, Universitas Muhammadiyah Kupang
Jl. KH. Ahmad Dahlan No 17 Kupang, East Nusa Tenggara, Indonesia
[2]Department of Fishery, Faculty of Marine Science and Fishery, Universitas Hasanuddin
Jl. Perintis Kemerdekaan, Tamalanrea 90245, Makassar, Indonesia
Email: susyherawaty17@gmail.com

***Abstract***

*Mackerel scad (Decapterus macarellus) is a fish resource that contributes to the economic sector for fishermen in the province of East Nusa Tenggara province. Its production has increased every year. This study aims to analyze the parameters of the population dynamics of the mackerel scad. Fish samples were collected at the Oeba Fish Landing Base Kupang from April to June 2020. The data analysis used included size structure analyzed descriptively, age group using the Bhattacharya method, growth parameter values (L∞ and K) based on the von Bertalanffy equation, natural mortality using the Pauly method, and Y/R using the Beverton and Holt method. The results showed that the smallest size of the mackerel scad was 7.8 cm (FL), the largest size was 27.8 cm (FL), the average length was 19.63 cm (FL) ± 4.46, the asymptotic length (L∞) = 38.10 cm (FL), the growth parameter value (K)= 0.51 year$^{-1}$, t0= -0.2996 year$^{-1}$, The population consists of two to three age groups. the total mortality value (Z)= 2.29 year$^{-1}$, natural mortality (M) = 1.08 year$^{-1}$, fishing mortality (F)= 1.22 year$^{-1}$ and exploitation rate (E)= 0.53 year$^{-1}$. The actual Y/R value was 0.057 and the relative Y/R was 0.060 grams recruit$^{-1}$*

***Keyword:*** *Age, growth, mortality, exploitation, mackerel scad, Timor Sea*

## INTRODUCTION

Small pelagic fish are a group of schooling fish that migrate vertically and horizontally (Nelwan et al., 2015) found in near-shore environments and continental shelves at depths of up to 200 m and have a length size range of 7 – 25 cm (Xu et al., 2023) has a fast growth rate with high natural mortality (Sadhotomo & Atmaja, 2012). One of the small pelagic fish that is widely found throughout tropical, and subtropical is the scad (Decapterus spp), this fish is an economically and ecologically important species (Feuilloley et al., 2020) and is one of the largest catch in the world (FAO, 2022).

The scad is a small pelagic fish resource that contributes greatly to the number of fish catches and plays a role in the economic sector of fishermen in the province of East Nusa Tenggara. Especially in the city of Kupang, the number of small pelagic fish production dominates, with a total production of 987.99 tons (2018) and 2019 an increase of 3.4% (1 021.68 tons)(BPS). One of the largest fish landing places in the city of Kupang is at the Oeba Fish Landing Base, based on data on the production of mackerel scad (*Decapterus macarellus*) landed at the Oeba Kupang Fish Landing Base in 2017 amounting to 81,864 kg, in 2018 there was an increase of 33% with total production was 109,343 kg, in 2019 it again increased by 90% (208,163 kg) then in 2020 it increased by 11% with total production of 231,219 kg. The Fishing fleets used by fishermen in Kupang include handlines, purse seines, trawlers, haulers, and lampara. The existence of this fish dominates so it is more popular than other types of fish.

The amount of production that continues to increase is partly due to high demand and consumer purchasing power. This condition encourages fishermen to fish on a large scale, one of which can be seen from the development of variations in fishing fleets. Pressure and competition also cause fishermen to use various methods including modifying fishing gear (Firdaus et al., 2017). Apart from that, facts on the ground show that not all fishing gear used by local fishermen meet environmentally friendly criteria, there is still the use of prohibited fishing gear, such as trawling because it causes damage to the ecosystem and threatens the sustainability of fish resources (FAO, 1995; Tarsono & Prasetyo, 2017).

*) Corresponding author

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The same thing was also conveyed by Nanlohy, that the use of fish resources throughout the world leads to overfishing (Nanlohy, 2013) If this condition continues, it will have an impact on the sustainability of fish resources(Safitri & Yustitianingtyas, 2023) because the increase in the fleet causes a decrease in catch rates, which indicates that scad have been caught more (Zamroni et al., 2019) this condition is characterized by small fish caught (Herwaty et al., 2021) decreased growth rate, and limited variation in age groups (Arreguín-Sánchez, 2000). It is feared that excessive use of fish resources without following fishery resource management principles will cause stock degradation and could lead to species extinction (Hanafi A et al., 2019). In utilizing natural resources, accurate studies and information are needed so that fish resources can be sustainable (Vidyastari et al., 2020), and can be used as a reference to ensure appropriate use of a stock (Sululu et al., 2022).

Research on mackerel scad has been carried out in several locations, including (Pattikawa et al., 2018) some biological aspects of mackerel scad (*Decapterus macarellus*) in Ambon island waters Indonesia, (Silooy *et al.*, 2019) population dynamics of mackerel scad (*Decapterus macarellus*) in the Banda Sea, (Vieira, 2018) stock assessment and the influence of environmental parameters on the distribution of mackerel scad (*Decapterus macarellus*) in Cabo Verde waters, (Bintoro *et al*., 2020) biological aspect of mackerel scad (*Decapterus macarellus* Cuvier, 1833) in Prigi waters Trenggalek Regency East Java Indonesia, and (Tenriware et al., 2023) biological reproduction of mackerel scad, Decapterus macarellus (Cuvier,1833) caught by purse-seine net in Majene Waters, West Sulawesi, Indonesia. Research on population dynamics of mackerel scad in the waters of the Timor Sea, East Nusa Tenggara Province never been carried, while the indications of exploitation pressure on fish resources are very high, so it needs to be investigated.

Based on the description above, it is necessary to study the population dynamics of the mackerel scad in the waters of the Timor Sea, East Nusa Tenggara Province. This study aims to analyze the population dynamics parameters (size structure and age group, growth rate, mortality, exploitation rate, and catchable-size) of mackerel scad in the waters of the Timor Sea, East Nusa Tenggara Province.

## MATERIAL AND METHODS

The sampling and measurements were carried out at the Oeba Fish Landing Base, Kupang, East Nusa Tenggara Province, Indonesia. The research location was presented in Figure 1. The materials and types of tools used in this study include mackerel scad, stationery, fish measuring instruments, cameras, computers, and software (Ms excel and FISAT II).

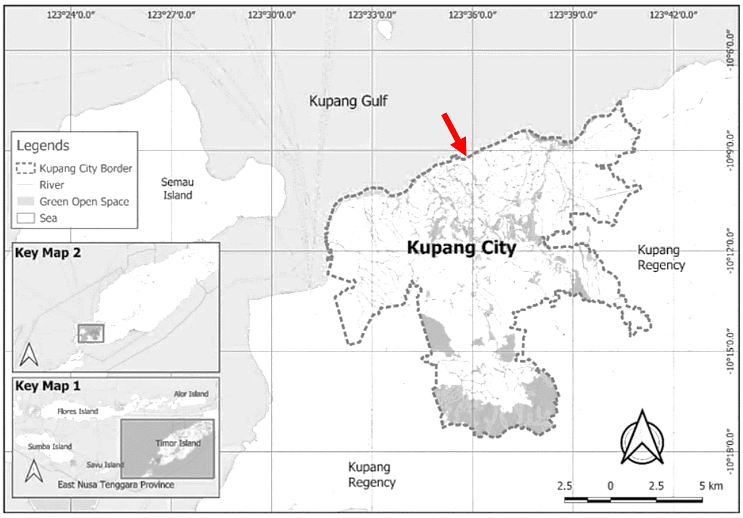


**Figure 1.** The sampling site location at the Oeba Fish Landing Base Kupang, East Nusa Tenggara Province, Indonesia, coordinates 10°09'17.1"S 123°35'25.9"E

Fish sample measurements were carried out for three months (April – June). A sampling of fish was carried out once a week using stratified random sampling from the smallest to the largest size that could represent the entire sample by grouping the fish caught based on the classification of small (<10 cm), medium (10-20 cm), and large (>20 cm). The measurement of fish samples was carried out by measuring the fork length (FL) using a length-measuring device with an accuracy of 1 mm. The number of samples collected during the research was 1219. The size structure of the fish was analyzed descriptive by displaying the percentage of long class intervals from the number of samples of the mackerel scad and displayed in the form of a histogram. Age group estimation was carried out by means of length-frequency analysis which was processed using the Bhattacharya method and displayed in a column diagram. The growth coefficient (*K*) and asymptotic length (*L∞*) of fish were obtained based on the von Bertalanffy equation:

$$Lt = L\infty\left[1 - e^{-k(t-t_0)}\right]$$

Where *Lt* is the length at age *t*, *L∞* is the asymptotic length the fish reach if they grow indefinitely, *K* is the growth coefficient

The hypothetical age (in years) the fish would have had at zero length ($t_0$) was estimated by Pauly's empirical equation (Zamroni et al., 2019) where *L∞* and *K* are the growth parameters from the Von Bertalanffy function :

$$\text{Log}(-t_0) = -0{,}3922 - 0{,}2752\ (\text{Log } L\infty) - 1{,}038\ (\text{Log } K)$$

Estimation of the growth parameters *L∞* and *K* were found from length frequency distribution in catches using the Von Bertalanffy equation in Shepherd's model routine of the FISAT II software

The total mortality (*Z*), was estimated by the length converted catch curve in FISAT II, with the Von Bertalanffy parameters *K*, and *L∞*. Total mortality was estimated from the slope of a catch curve with a negative slop given by the following equation: (Vieira, 2018)

$$\text{ln} = \frac{Ni}{\Delta ti} = a \div b * t_i$$

Where *Ni* is the number of fish in length class *i*, Δ*ti* is the time needed for the fish to grow through length class *i*, *ti* is the age (or the relative age, computed with $t_0$ = 0) corresponding to the midlength of class *i*, and where *b* is the regression slope and *a* is the intercept

The natural mortality (*M*) was estimated by Pauly's empirical formula, calculated using the Von Bertalanffy parameters *K*, *L∞* and *T* is the annual mean of the water temperature (°C).(Herwaty et al., 2023)

$$\text{Log}(M) = -0{,}0066 - 0{,}279 \log(L\infty) + 0{,}6543 \log(K) + 0{,}4634 \log(T)$$

The fishing mortality rate (F) was assumed by using the equation:

$$F = Z - M$$

The exploitation rate (E) was determined by comparing the fishing mortality rate (F) with the total mortality rate (Z)

$$E = F / Z$$

Yield Per Recruitment (Y/R), obtained from the equations of Beverton and Holt namely: (Herwaty et al., 2023)

$$Y/R = E.U^{M/K}\left[1 = \frac{3u}{1 \mp m} \mp \frac{3u^2}{1 \mp 2m} - \frac{u^2}{1 \mp 3m}\right]$$

$$U = 1 - \frac{L_c}{L_\infty}$$

$$m = \frac{1 - E}{M/K}$$

Where *Lc* is the length of the fish at age *t*, *K* is the coefficient of growth rate (year$^{-1}$), *Z* is the total mortality rate (year$^{-1}$), *M* is the death rate due to natural factors, and *E* is the Exploitation Rate (year$^{-1}$) then all these parameters were analyzed further using the FAO-ICLARM Stock Assessment Tools - II (FiSAT II) program.

The size of fish suitable for catching following the results of Widiyastuti's study which explains that the average size of the first mackerel scad caught (Lc50) was 23.22 cm (FL) ( Widiyastuti *et al.*, 2021). The percentage of the suitable size to be caught was calculated using the Mallawa equation (Herwaty *et al*., 2021):

$$I_E \ = \ [I_s / I_T] \times 100\%$$

Where $I_E$ is the number of fish that deserves to be caught (%), $I_S$ is the number of fish that have spawned, $I_T$ is the total number of fish caught or sample fish

**RESULTS AND DISCUSSION**

Mackerel scad (*D.marcellus)* samples that were collected during the study were 1219 individuals, the smallest fish size was 7.8 cm (FL) while the largest size was 27.8 cm (FL), class width was 2, the number of classes was 11 so that the length class interval was 7.8 – 28.8 cm (FL), the average length was 19.63 cm (FL) ± 4.46. The largest size of the mackerel scad caught was within the long class interval 19.8 - 20.8 cm (FL) as many as 215 individuals (18%), then in the class interval 23.8-24.8 cm (FL) as many as 232 individuals (19%). The size structure of the mackerel scad was presented in Figure 2.

The mackerel scad (*D. macarellus*) which was caught during the study had a size that was not much different from other locations. The size distribution of the scad in the waters of the Ambon islands ranged from 11.0 - 24.5 cm (FL) (mean 17.22±2.48 cm) (Pattikawa *et al*., 2018), a study found that the length of the mackerel scad in Ambon waters ranges from 9.5 - 31.8 cm (FL) (Silooy *et al*., 2019) while a study in the Banda Sea obtained lengths ranging from 9.0 - 31.9 cm (FL) with an average class length of 20.11cm (FL)(Silooy *et al*., 2019), Baihaqi's study in Sulawesi Seas obtained a length range of 14.25 – 30.75 cm (FL) (Baihaqi *et al*., 2021), while the same study showed more extended fish sizes, including in the waters of Prigi, Trenggalek district, East Java, it has a length of 16.8 - 35 cm (FL)(Bintoro *et al*., 2020), and the results of Costa's study in Cabo Verde reported that female scads have a length range of 20 -36 cm (FL), male scad with a length range of 21–35 cm (FL)(Costa *et al*., 2020). The distribution of fish size structures in a body of water is relative and thought to be related to water conditions that support the upwelling process so that food availability is abundant (Haruna et al., 2018) gonad maturity, the more fish that have mature gonads and have spawned indicate the size structure of large fish is dominant caught (Widiyastuti et al., 2020) variations in the type of fishing gear used (Silooy et al., 2019) and environmental changes resulting in changes in ecological conditions and marine ecosystems (Widianingsih et al., 2023), while Sari stated that the fishing season and peak fishing season also affect is that the size structure of the fish more varied (Sari et al., 2021).

The results of analysis using the Bhattacharya method showed that mackerel scad (*D. macarellus*) caught during the research in the first month consisted of three age groups with the average individual length of group I being 11.46 cm (FL) ± 1,490, group II being 16.85 cm (FL) ± 1,830 and group III 22.97 cm (FL) ± 3,160. The second-month sampling consisted of two age groups with the average length of age group I being 15.62 cm (FL) ± 3,450 and age group II 24.00 cm (FL) ± 2,820, while sampling in the third month consisted of three age groups with average individual length of group I was 12.08 cm (FL) ± 1,780, group II was 16.11 cm (FL) ± 1,611 and group III was 24.77 cm (FL) ± 2,630. The composition of the size and number of mackerel fish is presented in Figure 3.

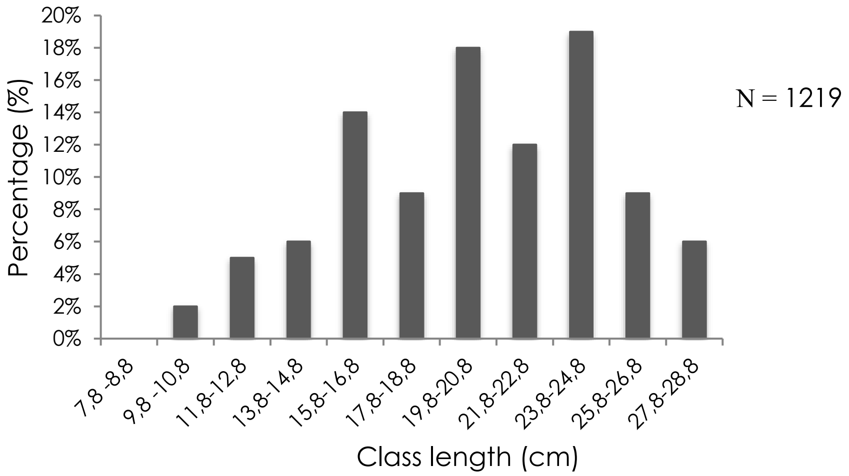


**Figure 2**. Size structure of the mackerel scad (*D. macarellus*) in the waters of the Timor Sea

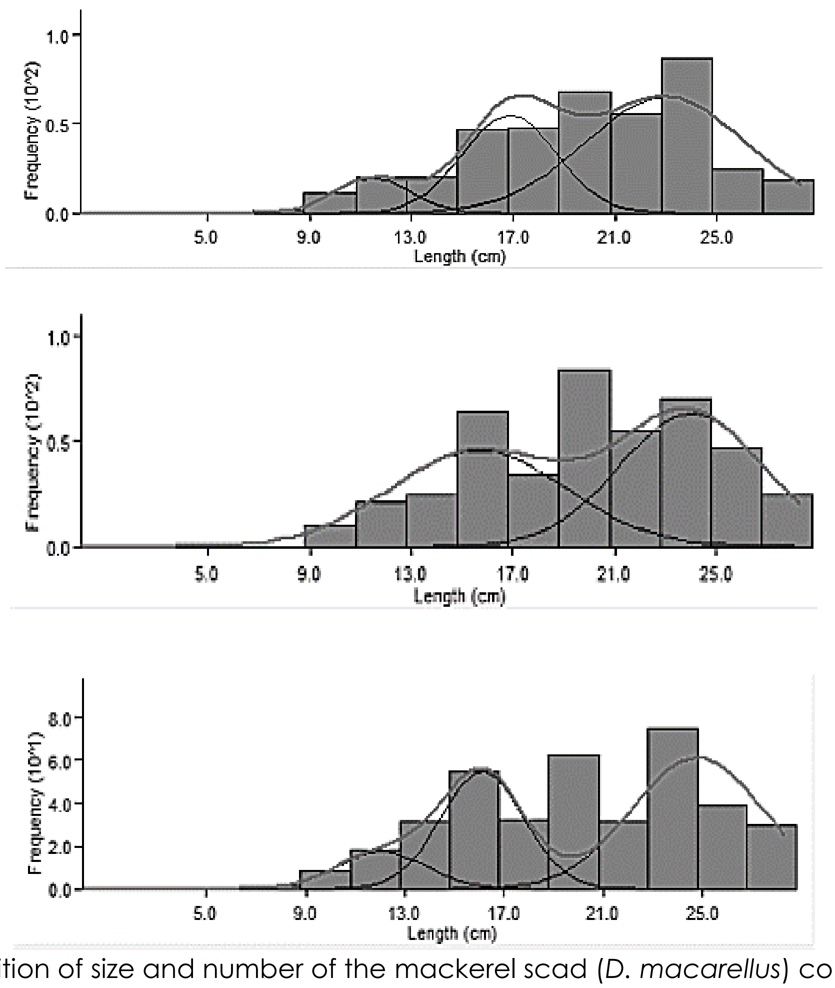


**Figure 3**. Composition of size and number of the mackerel scad (*D. macarellus*) cohort in the waters of the Timor Sea

By using Bhattacharya's method obtained the frequency distribution of the mackerel scad (*D. macarellus*) as shown in Table 1. The data in Table 1 shows that the number of mackerel scad age groups during the study consisted of two to three age groups, this condition shows that the dominant fish caught were young to pre-adult fish. Figure 3 shows that in the first month sampling consisted of three age groups, sampling in the second month consisted of two age groups, and sampling in the third month consisted of three age groups, based on this condition the average varied length was obtained. The results of research in the waters south of Ambon, Eastern Indonesia obtained four age groups with a frequency distribution mode occurring at mid-length 20.5 cm (FL) (Silooy *et al*., 2021). The number of age groups/cohorts in waters is relative and dynamic, water conditions and parameters, food availability, and several other aspects influence the number of cohorts/age groups. Apart from that, this condition is thought to also be influenced by the number and composition of samples taken during the research period.

Growth parameter analysis was carried out using FISAT II software, ELEFAN I program with visual response surface analysis, and automatic search analysis so that the values of K, L∞, and Rn (Goodness of fit) were obtained (Table 2). The growth rate of the mackerel scad (*D. macarellus*) was presented in Figure 4. From the length of the infinity mackerel scad (L∞), the growth rate (K) and the value of t0 ($-0.2996^{-1}$) could be obtained the growth equation of Von Bertalanffy. Based on equation of Von Bertalanffy, the curve of the relationship between age and length of mackerel scad was obtained as shown in Figure 5.

Growth can be formulated as an increase in length or weight over time. The growth coefficient determines how quickly the fish reaches its asymptotic length, fish with a high growth coefficient generally have a shorter lifespan (Bintoro *et al*., 2020). The value of the coefficient of growth rate (*K*) of mackerel scad (*D. macarellus*) at the research site was 0.51 per year, this condition explains that to reach the asymptote length of mackerel scad in the waters of the Timor Sea, East Nusa Tenggara requires a relatively fast time (*K* >0.5). In the following Table 4, previous studies in different locations are presented, which show different values of the von Bertalanffy growth parameters (*L∞*, *K*, and $t_0$).

**Table 1**. Decomposition of composite distributions using Bhattacharya's method

| Month of collection | Amount Age group | Mean | SD | Population | S. I |
|---|---|---|---|---|---|
| Ffirst month (April) | I | 11.46 | 1.490 | 39 | n.a |
| | II | 16.85 | 1.830 | 129 | 2.320 |
| | III | 22.97 | 3.160 | 263 | 2.120 |
| Second month (Mei) | I | 15.62 | 3.450 | 199 | n.a |
| | II | 24.00 | 2.820 | 226 | 2.220 |
| Third month (Juni) | I | 12.08 | 1.780 | 39 | n.a |
| | II | 16.11 | 1.611 | 117 | 2.090 |
| | III | 24.77 | 2.630 | 207 | 2.430 |

**Table 2.** *L*, *K* and $t_0$ values of the mackerel scad (*D. macarellus*) in the water of the Timor Sea

| Parameters | Value |
|---|---|
| Asymptote Length, L∞ (cm) | 38.10 |
| Coefficient of growth rate, K( per year) | 0.51 |
| Rn (*Goodness of fit*). | 0.504 |
| The theoretical age of fish length is equal to zero, (years) | -0.2996 |

**Table 4**. Estimated growth parameters of the mackerel scad in different locations

| Area | L∞ | K(year$^{-1}$) | $t_0$(year$^{-1}$) | Reference |
|---|---|---|---|---|
| Prigi waters, East Java | 38.73 cm | 0.77 | -0.194 | (Bintoro *et al*., 2020) |
| Republic of Cabo Verde waters | 40.6 cm | 0.45 | -0.340 | (Vieira, 2018) |
| West Africa | 40,9 cm | | | (Palomares et *al*., 2020) |
| Banda Sea | 33.35 cm | 0.56 | -0.279 | (Silooy *et al*., 2019) |
| This study | 38.10 cm | 0.51 | -0.299 | Herwaty et al |

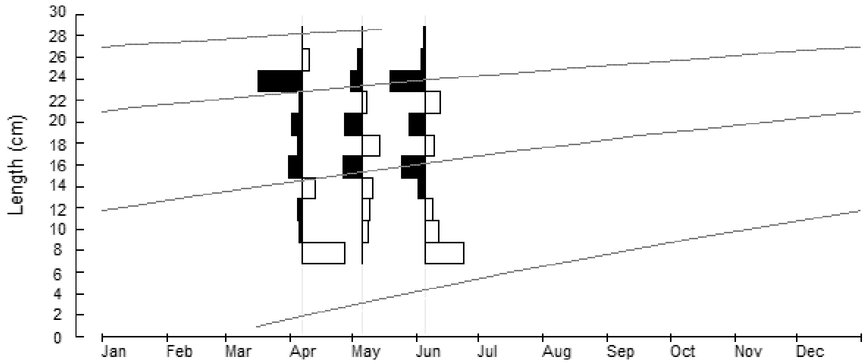


**Figure 4.** The growth rate of Von Bertalanffy mackerel scad (*D. macarellus*) in the waters of the Timor Sea

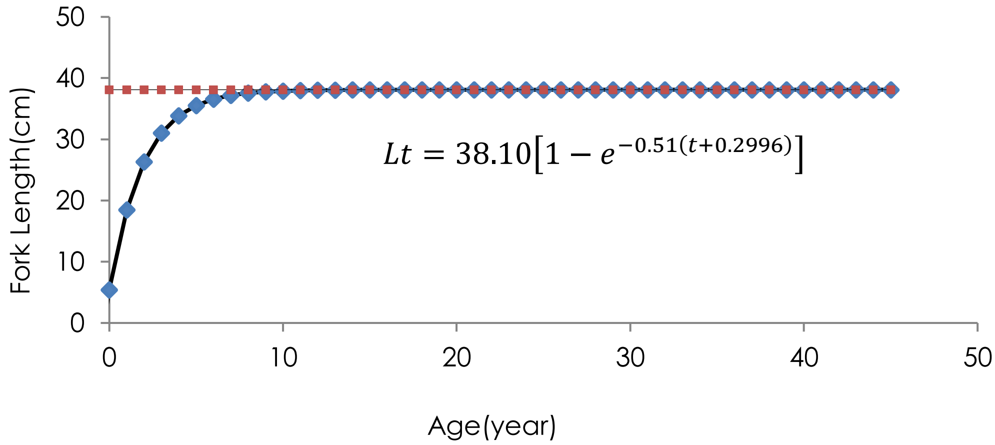


**Figure 5**. Von Bertalanffy's growth curve of the mackerel scad (*D. macarellus*) in the waters of the Timor Sea

Factors that influence the differences in fish growth are thought to be due to differences in the location and time of the study as well as the number and composition of samples taken during the study. According to Viera the value of the mackerel scad growth parameter depends on the geographical area, the fishing gear used and the habitat conditions (Vieira, 2018), Wardani stated that the difference in growth caused by internal factors was thought to be due to heredity, gender, age, and disease (Wardani et al., 2021), while Ghosh stated that differences in environmental parameters, availability of food stocks, predation, exploitation and the type of fishing gear used will affect the growth rate (Ghosh et al., 2016). In Figure 5 it was known that the mackerel scad experiences a relatively fast growth rate at the age of 0 to 5 years, then the growth of the scad in the waters of the Timor Sea, East Nusa Tenggara slows down with increasing age until it reaches its asymptotic length. According to Suwarni et al that rapid growth occurs in fish when they are 3-5 years old, in older fish growth is slow. Old fish generally lack food for growth, because most of their food is used for body maintenance and movement (Suwarni et al., 2015). The same thing was conveyed by Nursinar & Panigoro, that the increase in fish body length can be calculated for each year until it reaches its maximum length. The increase in length of the fish will decrease as the age of the fish increases, so that at one time the increase in length approaches zero (Nursinar & Panigoro, 2015).

The results of the calculation of the total mortality of the mackerel scad (*D. macarellus*) using the "Length converted catch curve" method and natural mortality using Pauly's empirical formula, the parameters entered include the values of L∞, K, t0, and the average temperature during the study. The results of the analysis in order to obtain the values of Z, M, F, and E were presented in Table 3. Length converted catch curve was presented in the Figure 6.

The fishing mortality value (F) was classified into: F < 1 = low, F = 1.0 - 2.0 is high and F > 2.0 is very high (Herwaty et al., 2021). The death rate due to fishing at the research location is relatively high (F=1.22). The cause of the high fishing mortality rate is thought to be due to the high level of utilization of mackerel scad in these waters, according to Alnanda this condition is due to the increasingly intensive fishing efforts carried out by fishermen using various fishing gear. The increasing number of fishing gear and fishing intensity causes a mortality coefficient as a result of arrests has also increased (Alnanda et al., 2020). Fadhilah stated that suitable environmental conditions will increase fishing efforts so that this period is the peak fishing season(Fadhilah et al., 2021), but on the contrary, increasing fishing efforts cause biomass abundance to decrease (Purwanto et al., 2022), and the

**Table 3.** *Z, M, F* and *E* values of the mackerel scad in the waters of the Timor Sea

| Mortality value | Estimated value ((year$^{-1}$) |
|---|---|
| Total mortality (Z) | 2.29 |
| Natural mortality (M) | 1.08 |
| Fishing mortality (F) | 1.22 |
| Exploitation rate (E) | 0.53 |

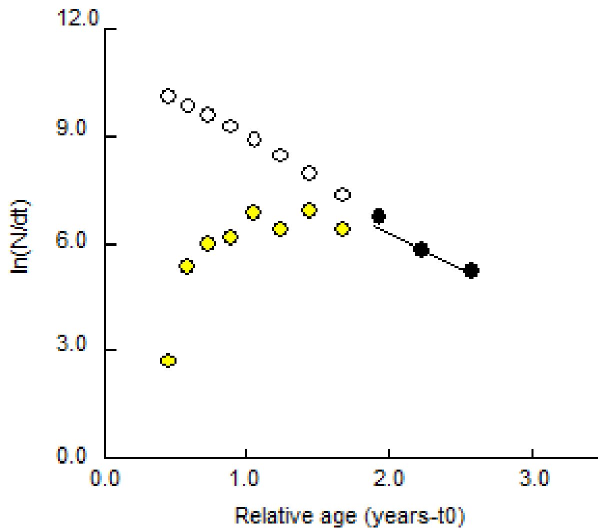


**Figure 6.** Length converted catch curve of the mackerel scad (*D. macarellus*) in the waters of the Timor Sea

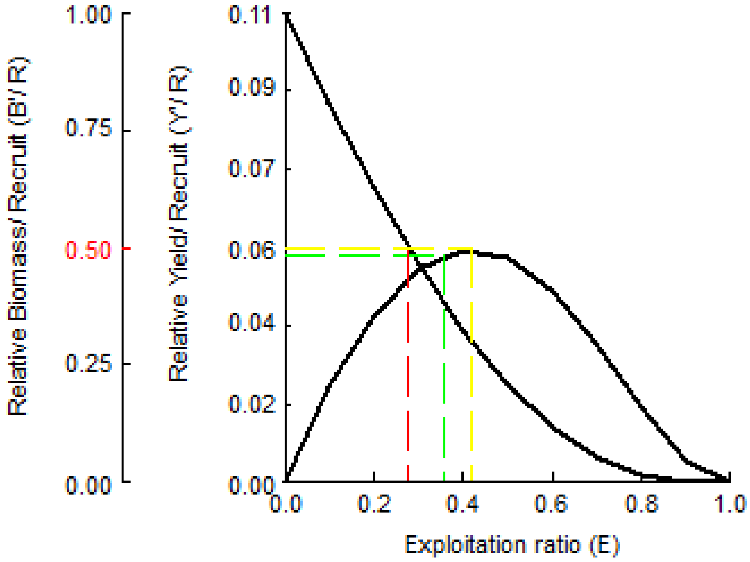


**Figure 7**. Model Relative Yield-per-Recruit (Y/R) Beverton & Holt mackerel scad in the waters of Timor Sea

genetic diversity of a species also decreases (Zamroni & Suwarso, 2018). The natural fishing mortality rate at the research location was low (M=1.08). Low natural mortality and high fishing mortality can indicate a suspected overfishing condition, namely that more young fish are caught while older fish are caught less (Sparre & Venema, 1998). The results of Bintoro's research in the Prigi waters of East Java obtained a value of Z = 3, 0, M = 0.28, F = 2.71, and E = 0.905/year (Bintoro et al., 2020), while the results of other research in the Banda Sea obtained Z = 2.58, M = 1.23, F = 1.36, and E value = 0.53/year (Silooy et al., 2019). Differences in fish mortality (M) values in waters are estimated to be influenced by differences in time, fish size distribution at the time of sampling, and water conditions, while according to Silooy, this is caused by the condition of the aquatic environment, and the physical condition of the fish including food availability, predation, old age and disease (Silooy et al., 2019). Estimating the Y/R value using the Beverton and Holt equation, by entering the values of L∞, K, F, M, and E, then the relative Y/R value was 0.060 grams per recruit, and the actual Y/R value was 0.057 grams per recruit (Figure 7).

The Y/R value of the mackerel scad in the waters of the Timor Sea, East Nusa Tenggara is not optimal where the actual Y/R is smaller than the Y/R relative. The exploitation value (E) of mackerel scad fish is obtained from a comparison between the mortality value due to fishing (F) and the total mortality value (Z). The level of exploitation at the research location is E = 0.53, this condition shows that the exploitation value is E > 0.5, thus indicating that overfishing conditions are occurring. On the other hand, if the exploitation level value is (E = 0.5), then the stock is in a healthy condition and exploitation is carried out optimally (Herwaty et al., 2021). The growth rate of mackerel scad fish at the research location is 0.51, which indicates that the growth rate is relatively fast (K > 0.5). According to Sparre & Venema, fish that have a high growth rate value need a faster time to reach their maximum length. The faster the fish reaches maximum size, the faster the fish will reach mature gonad size and spawn, so that fish recruitment will not be greatly disrupted even though the level of exploitation is high (Sparre & Venema, 1998).

Based on the measurement results of 1219 samples of the mackerel scad, the percentage of suitable size for catching was 34% (416 individuals) with a long class interval of 23.8 -28.8 cm (FL) and 66% (803 individuals) was the size of the fish that are not suitable for catching with long class intervals 7.8 – 21.8 cm (FL). The mackerel scad size of fish suitable for catching in the study area was low (below 50%). From 1219 fish samples obtained consisted of young to adult fish, and the dominant fish were young fish and pre-adult fish. From 1219 fish samples obtained consisted of young to adult fish, and the dominant fish were young fish and pre-adult fish. While the results of Kadir's study in the Ternate

Sea obtained that the size of fish suitable for catching using gillnets was 0%, while the size of fish suitable for catching using handlines was 1.3% (1.121 samples) (Kadir *et al*., 2021). The catchable size of fish in an area varies, this condition is influenced by the level of maturity of the gonads when the fish is caught, fish caught after going through the spawning process are declared a suitable size for catching. Widiastuti's study in the Indian Ocean West of the Sumatran block obtained that the size of the first fish caught was 25.08 cm (FL)(Widiyastuti *et al*, 2020) and Bintoro reported that the first mackerel scad caught in the waters of Prigi, Trenggalek, East Java was 26.68 cm (FL) (Bintoro *et al*., 2020). The composition of the dominant fish size caught was small can be an indicator that more young fish are caught than adult fish so it will affect the population. The distribution of fish size composition is the basis for determining the size of fish suitable for catching because fish size is related to gonad maturity, fishing gear, and water parameters. According to Liestianan, the use of mesh size must be adjusted to obtain fish that are large and have spawned (Liestiana et al., 2015) while Agustina stated the difference occurred through to be due to temperature, food, sex, hormones and water conditions(Agustina et al., 2016).

## CONCLUSION

Mackerel scad in the Timor Sea waters of East Nusa Tenggara have a length range of 7.8 – 28.8 cm FL, the dominant mackerel scad caught are in the length class intervals of 19.8-20.8 and 23.8-24.8 cm FL. Consisting of two to three age groups, including young fish, pre-adults, and adult fish, they have a relatively fast growth rate so that they reach their asymptote length (L∞) more quickly. The fishing mortality rate is relatively high, allegedly due to increasingly intensive fishing efforts carried out by fishermen. Y/R is not optimal where the actual Y/R is smaller than the relative Y/R, level of exploitation at the research location E = 0.53 indicates an exploitation value of E> 0.5 (condition overfishing), and the number of catchable fish caught during the research period was still low (<50%).

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