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# Structure of size and growth pattern of frigate mackerel *(Auxis thazard)* in fish landing base of ujong baroh meulaboh

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**Abstract**
Frigate mackerel (*Auxis thazard*) is a pelagic fish and belongs to a member of the family Scombridae. It is found in almost all tropical and subtropical seas, and even often found in Indonesian waters, especially the waters of West Aceh. Information related to the growth pattern of the fish provides a fundamental advantages for the management of fishery resources in the waters of West Aceh. This research aimed to investigate the length and biological characteristics of frigate mackerel landed on Fish Landing Station (PPI) of Ujong Baroh Meulaboh. The fish length was determined through observation and measurement. The fish samples were randomly taken twice a week from January 2016 to July 2016. The frequency of the fish length for the determination of class interval was analyzed using distribution formula, while FISAT II program was applied to assess biological characteristics. The results showed that the length of frigate mackerel caught by boat seine *(Pukat payang)* was 19-46 cm. From January to July 2016, the length of the fish is dominated by size 34 and 35 cm, from February to June 2016, the length of the fish is dominated by size 22 and 25 cm. The length of a fish with the first thought was 31.51 cm with asymptotic length $L\infty$ of 48.3 cmFL, growth rate K of 0.86 years$^{-1}$, while the growth rate of fish at zero length (t0) was 0.119 years$^{-1}$. The results also showed that total mortality Z and natural mortality M were 1.48 years$^{-1}$ and 1.46 years$^{-1}$, respectively, while fishing mortality F and exploitation rate E was 0.02 years$^{-1}$ and 0.01 years$^{-1}$, respectively.

**Keywords:** population structure, frigate mackerel (*Auxis thazard*), waters of west aceh, PPI ujong baroh meulaboh

## 1. Introduction
With a coastline length of 50.55 km and water area of 80. 88 km$^2$, West Aceh has a numerous diversity of ecosystems, contributing to various fish catches. This region is endowed with tremendous fishery products since it directly faces the Indian Ocean, which is rich in fish (Diana *et al.*) [6]. Fishing activities have provided great economical benefits for local communities, particularly in Meulaboh region. Currently, high intensity of fishing tends to ignore the sustainability of fish resources.

Frigate mackerel (*Auxis thazard*) is a pelagic fish and a member of the family Scombridae. This fish is mostly available in all tropical and subtropical waters (Collette & Aadland [4]; Tao *et al*., [27]; Hartaty and Setyadji) [10].

The fish is neuritis often found at sea level up to 50 m depth (Herera & Pierre [11]; Maguire *et al*., [17]; Collette & Nauen; [3]; Hartaty and Setyadji [10]). IOTC [12] reported 4 countries that accounted for more than 90% of frigate mackerel catches, including Indonesia (59%), India (14%), Sri Lanka (11%) and Iran (7%).

Understanding the biological characteristics of frigate mackerel is essential to enhance resource management. The characteristics include the growth pattern of frigate mackerel. Previously, several studies pertaining biological aspects of frigate mackerel in west waters of Sumatra have been reported by Noegroho *et al*., [18]; Dwiponggo *et al*., [7]; Widodo *et al*., [29] and in the southern waters of Java reported by Hartaty and Setyadji) [10].

Frigate mackerel landed in PPI Ujong Baroh was captured in the waters if West Aceh by using purse seine, gill net, boat seine, and handling with or without fishing aggregating devices (FADs). Frigate mackerel catch has annually increased, although it is not known whether the caught fish is feasible or not in term of fish growth.

The research was designed to describe the growth pattern of frigate mackerel, which could provide data related to the determination of the proper fish size to capture by fishermen. This enabled to offer a guidance for resource management of frigate mackerel in the waters of West Aceh, leading to an optimal fish capture without degrading fish resource. This study aimed to investigate the fish length, and analyze the biological aspects of frigate mackerel landed in PPI Ujong Baroh Meulaboh.

## 2. Materials and Methods
The study was conducted in PPI Ujong Baroh Meulaboh from January 2016 to July 2016. Fish length was obtained through observation and measurement. Fish sample was randomly collected twice a week with regardless of their gender. Fork length (FL) of frigate mackerel captured using boat seine in the waters of West Aceh was determined using digital calipers (cm). Study site was depicted in Figure 1.

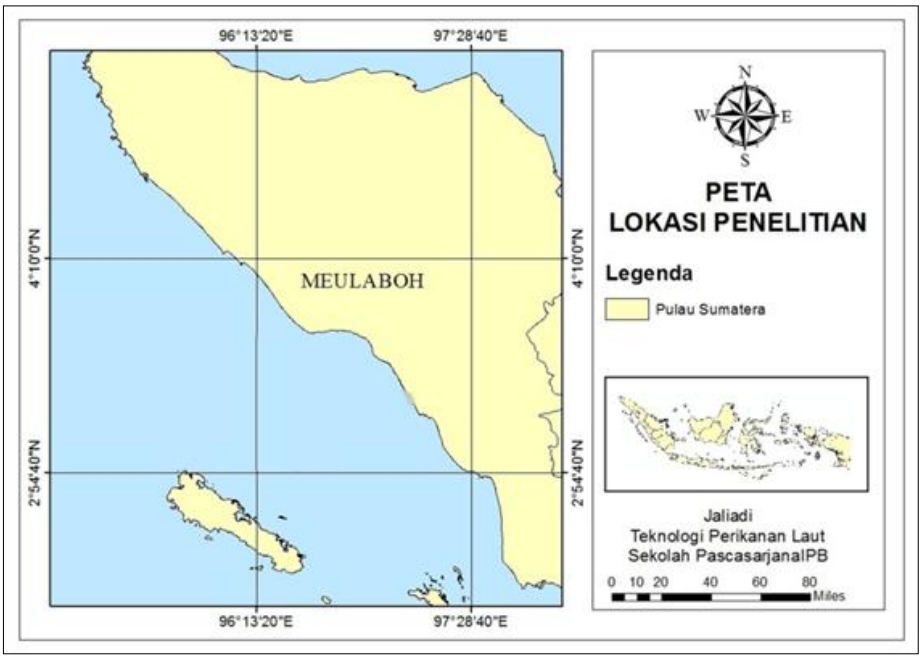



**Fig 1:** Study site of PPI Ujong Baroh Meulaboh

Length-frequency data would determine class interval, median, and frequency in each group. Fish length was measured using following frequency distribution formula (Walpole) [28]:

$$K = 1 + 3{,}32\ log\ n \quad \text{.....(1)}$$

$$i = R/K \quad \text{.....(2)}$$

Where:

*K* = number of class;
*N* = number of data;
*i* = class interval;
*R* = maximum value and minimum value.

Fish growth parameters (K and L) were estimated using sub-program ELEFAN I in FISAT II software (Gayanilo *et al*.,) [8]. Analysis based on fish length data was assessed using following growth formula including Von Bertalanffy Growth Function (VBGF) and (Beverton & Holt) [2]:

$$Lt=L\infty(1-e^{-k(t-t0)}) \quad \text{.....(3)}$$

Where:

Lt = fish length at age t;
L∞ = asymptotic length;
K = growth coefficient;
$t_0$ = theoretical age when the sample was at zero length.

The fish theoretical age could be estimated when the sample was at zero length. The following empirical formula (Pauly) [20] was used:

$$Log\ -(t_0) = 0{,}3922 - 0{,}2752\ (Log\ L) - 1{,}038\ (Log\ K) \quad \text{.....(4)}$$

The natural mortality (M) was estimated using empirical equations (Pauly) [19]:

$$Log\ (M) = -0{,}0066 - 0{,}279\ Log\ (L) + 0{,}654\ Log\ (K) + 0{,}4634\ Log(T) \quad \text{.....(5)}$$

where:

M = natural mortality;
L = asymptotic length;
K = growth coefficient;
T = average estimated temperature of 30 °C (Noegroho *et al*.) [18].

Total mortality (Z) was approached through total fish capture converted into fish length (length-converted catch curve) introduced by (Pauly) [21], with the assumption of the constant capture during observation (Punt *et al*.,) [23]. Length-converted catch curve was a plot of linear regression equation.
Measurement of both parameters indicated that fish mortality resulted from fishing activity (F), calculated as follows:

$$F = Z - M \quad \text{.....(6)}$$

Exploitation rate (E) was calculated by comparing F and Z (Pauly,) [20]:

$$E = \frac{F}{F+M} = \frac{F}{Z} \quad \text{.....(7)}$$

where:

M = natural mortality;
E = exploitation rate;
Z = total mortality;
F = fishing mortality.

Fish stock due to excessive capture was not based on optimal

value E ($E_{opt}$) > 0.50. This assumption also demonstrated that the continuous capture was obtained at F > M (Gulland,) [9].

## 3. Results

Figure 1 exhibits length frequency (19-46 cm) of frigate mackerel captured using boat seine from January 2016 to July 2016. Based on length-frequency data, frigate mackerel with a length of 22, 37, and 35 cm dominantly occurred in January, February, and June, while the fish with a length of 34 cm was dominant in March-June (Figure 2).

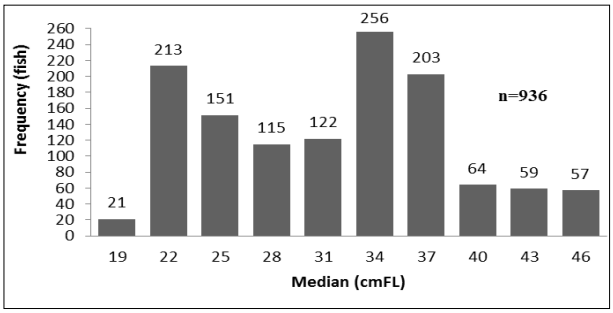



**Fig 2:** Length frequency of frigate mackerel captured using boat seine landed Fin PPI Ujong Baroh Meulaboh from January to July.

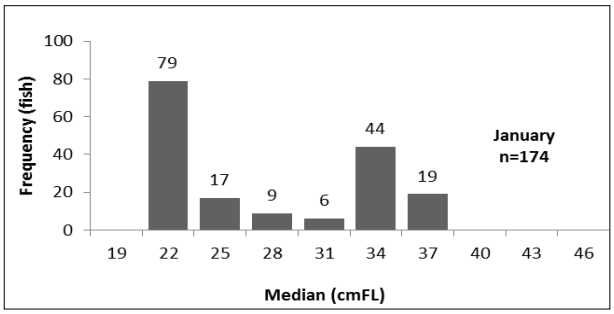
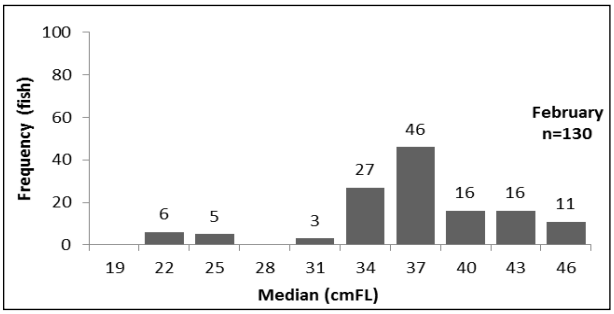



**Fig 3**

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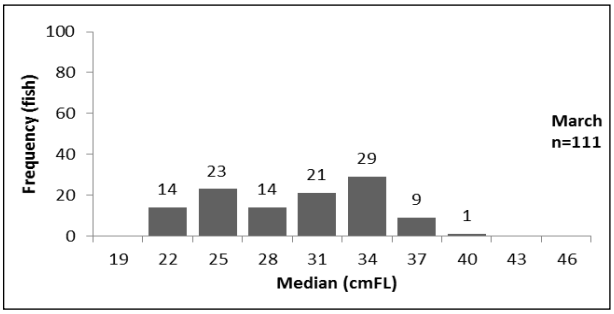
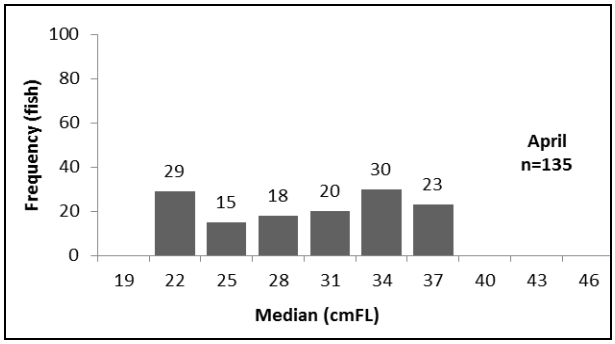



**Fig 5**

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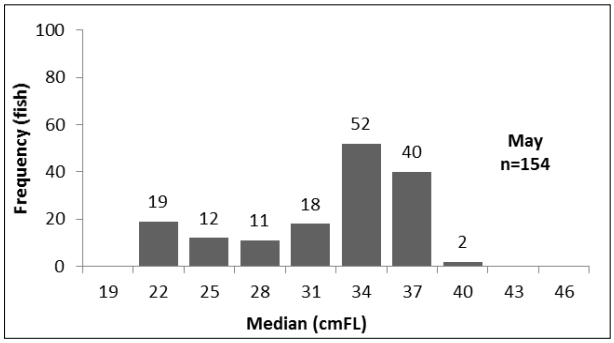


**Fig 7**

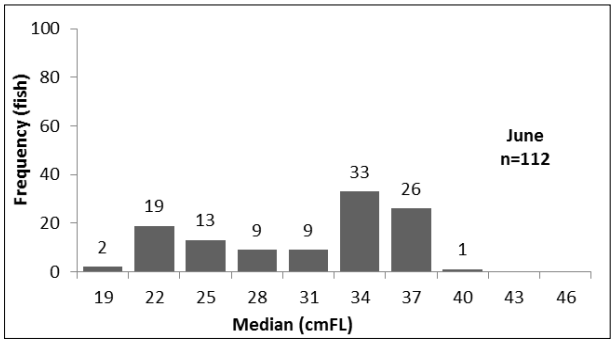


**Fig 8**

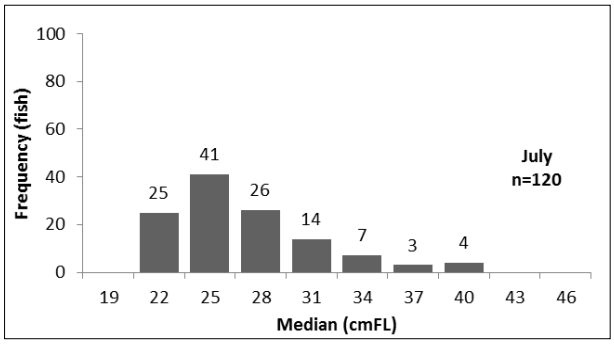


**Fig 9**

Figure 3-9. Monthly length frequency of frigate mackerel captured using boat seine landed Fin PPI Ujong Baroh Meulaboh from January to July

The results showed that length of fish that was first caught by fishermen in the waters of West Aceh and landed in the PPI Ujong Baro was 30.51 cm (Figure 10).

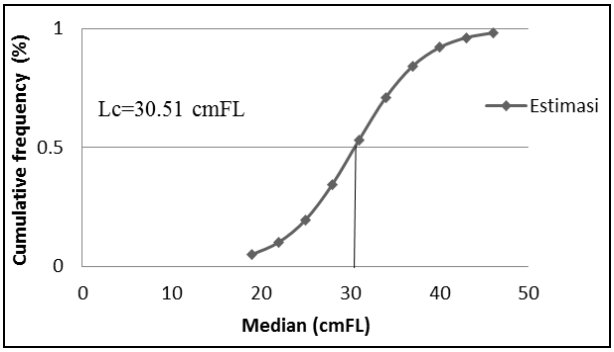


**Fig 10:** The length of first caught fish captured by boat seine in the waters of West Aceh and landed in PPI Ujong Baroh Meulaboh

Assessment of length-frequency data using FISAT II demonstrated asymptotic length L∞ of 48.3 cmFL, growth rate K of 0.86 year$^{-1}$ and growth rate when the specimen was at zero length ($t_0$) of 0.119 years$^{-1}$ (Figure 11). The results indicated that frigate mackerel in the waters of West Aceh could grow and reach a maximum length of 48.3 cm FL.

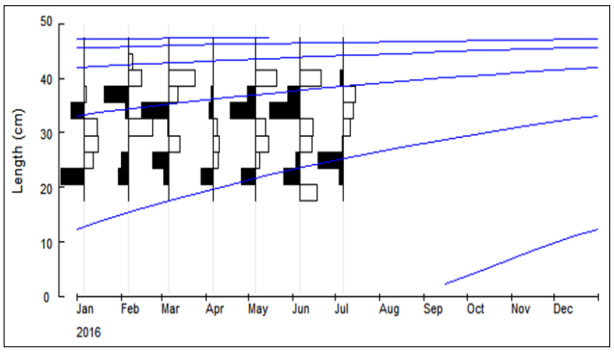


**Fig 11:** Growth curve of frigate mackerel captured using boat seine and landed in PPI Ujong Baroh Meulaboh

The result indicated that the equation of frigate mackerel growth followed curve von Bertalanffy Lt = 48.3(1-exp $^{(-0.86(t-0.119))}$). This equation enabled to describe a model curve of the relationship between fish age and fish length (Figure 12).

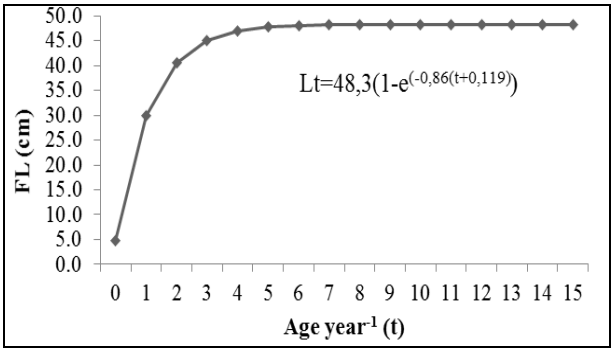


**Fig 12:** Growth curve of frigate mackerel captured using boat seine and landed in PPI Ujong Baroh Meulaboh

The results demonstrated total mortality Z of 1.48 years$^{-1}$, natural mortality M of 1.46 years$^{-1}$, fishing mortality F of 0.02 years$^{-1}$ and exploitation rate E of 0.01 years$^{-1}$ (figure 13)

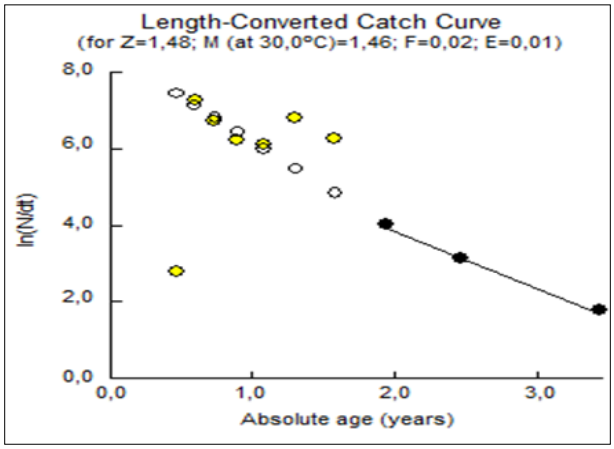


**Fig 13:** Fish catch based on length

## 4. Discussion

A total of 936 frigate mackerel was observed in this study, and the frequency, length was dominated by fish with 22 and 34 cm FL in length. Hartaty and Setyadji [10] found that frigate mackerel caught in waters of Sibolga in January-February, May, and September-December was dominated by fish with 35 cmFL in length, while in March-April and August the fish catch was dominated by fish with 29 cmFL in length.

Noegroho *et al*., [18] found a length of frigate mackerel caught in February and April in the western waters of Sumatra ranged from 21 to 40 cm. This wide length range is a consequence of different fishing tools and methods used by fishermen.

Abussamad *et al*., [1] reported that the length of frigate mackerel captured in Indian waters ranged from 18 to 56 cm, and dominated by 25-40 cm. In addition, Iswarya & Sujatha [13] found that length of frigate mackerel caught in the waters of North Andhra Pradesh, India was 30-46 cmFL. Robert *et al*., [24] reported that frigate mackerel caught in the waters of New Zealand had a length range of 26-41 cmFL. Tao *et al*., [27] reported that the length of frigate mackerel in the Taiwan Strait was 25-40 cm FL.

Hartaty and Setyadji [10] stated that the use of FADs in fishing was very influential on the catch. FADs are designed to attract fish in a place in which plankton and small fish are concentrated. Furthermore, Noegroho *et al*. [18] found that fish caught around FADs showed a similar size in each month. This is due to application of FADs. The schooling fish gather around FADs; thus, they are relatively similar in size. The fish are interested and associated with FADs temporary.

The maximum length of frigate mackerel caught in the waters of West Aceh and landed in PPI Ujong Baroh Meulaboh is expected to grow up to 48.3 cm with the coefficient of growth rate reaching 0.86 year$^{-1}$. Hartaty and Setyadji [10] reported that maximum length of frigate mackerel caught in waters of Sibolga was estimated to grow up to 47.9 cm with a growth rate coefficient of 0.58 year$^{-1}$. Table 1 exhibits the growth parameters of frigate mackerel from various waters.

**Table 1:** Growth parameters of frigate mackerel from various locations

| Location | L∞ (cm) | K year$^{-1}$ | References |
|---|---|---|---|
| Sri Langka | 58.0 | 0.58 | Joseph *et al.*, [14] |
| Indian waters | 57.95 | 1.2 | Abussamad *et al.*, [1] |
| Sibolga | 47.9 | 0.58 | Hartaty dan setyadji [10] |
| Waters of West Aceh | 48.3 | 0.86 | Current study |

Based on the catch curve, the first catch of frigate mackerel (Lc = 50%) in the waters of West Aceh landed in PPI Ujong Baroh Meulaboh had average size of 30.51 cm. Jude *et al*., [15] stated that the length of the first matures gonad frigate mackerel was about 30.8 cm for males and 32 cm for females. Schluderman *et al*., [25] showed that the growth rate of frigate mackerel was affected by internal and external factors. The significant external factors include competition and environmental factors such as food availability, temperature, and salinity (Litvak and Leggett, [16]; Pepin *et al*., [22]; Schluderman *et al*., [25]. Furthermore, Csirke [6] stated that diverse growth parameters of the same fish species in different locations resulted from environmental factors such as food availability, water temperature, dissolved oxygen, fish size and maturity level of gonads.

FISAT II analysis showed that frigate mackerel caught in the waters of West Aceh experienced a high natural mortality F of 1.46 years$^{-1}$ compared to fishing mortality (F). Sparre & Venema [26] stated that natural mortality occurred due to various causes not associated with fishing. Such cases included predation, disease, spawning stress, lack of food, and old age.

Furthermore, Pauly [19] found a direct relationship between natural mortality and environmental temperature. Environmental temperature could increase the growth rate, thus fish in the tropical seas required more food to meet their high metabolic needs. The low rate of fishing mortality was augmented by lowest exploitation rate (0.35), which was lower than the optimum exploitation rate (0.50). Therefore, this difference could be used for development of fisheries management in the waters of West Aceh Meulaboh.

## 5. Conclusion

Frigate mackerel captured in the waters of West Aceh and landed in PPI Ujong Baroh had a wide length range of 19-46 cm. The length of the first catch Lc using boat seine was 31.51 cm. Asymptotic length L∞ of frigate mackerel was 48.3 cm with growth rate K of 0.86 years$^{-1}$ and growth rate when the specimen was at zero length ($t_0$) of 0.119 years$^{-1}$. Other parameters included total mortality Z of 1.48 years$^{-1}$, natural mortality M of 1.46 years$^{-1}$, fishing mortality F of 0.02 years$^{-1}$ and exploitation rate E of 0.01 years$^{-1}$. This study concluded that there was necessary to increase fishing intensity on frigate mackerel species in the waters of West Aceh.

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