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SIZE STRUCTURE AND GROWTH PARAMETERS OF THE FRIGATE TUNA (Auxis thazard) LANDED IN THE PORT OF ANTSIRANANA (2014 – 2019)
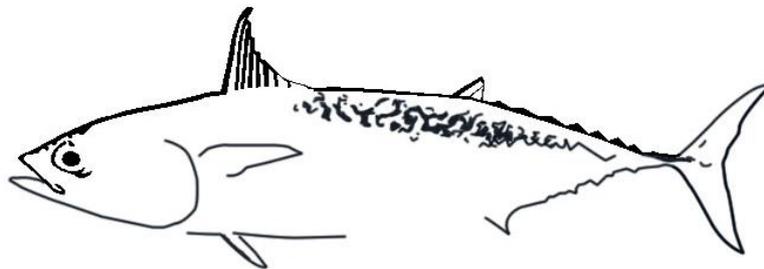
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SIZE STRUCTURE AND GROWTH PARAMETERS OF THE FRIGATE TUNA (*Auxis thazard*) LANDED IN THE PORT OF ANTSIRANANA (2012 – 2019)

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. In the period 2012-2019, 18 997 *Auxis thazard* were sampled, from the bycatch of European seiners who landed at the port of Antsiranana. The individuals are identified and measured according to the length at the fork (LF). The LFDA 5 program was applied to assess biological characteristics. The size frequency is dominated by the size between 40 cm and 42 cm. The estimated parameters of growth using the equation of Von Bertalanffy are: $L\infty$ = 48.41 cm and the K = 0.53 year^{-1}, t_0 = -0.071. The results also showed that total mortality Z and natural mortality M were 0.95 years^{-1} and 0.71 years^{-1}, respectively, while fishing mortality F was 0.24 years^{-1}.

Keywords: Frigate mackerel (*Auxis thazard*), age, growth parameter, mortality

1. Introduction

Madagascar is a large island in the Indian Ocean, surrounded by the Mozambique channel in the West and the Indian Ocean in the East. With a coastline length of 5 000 km, it has a numerous diversity of ecosystems, contributing to various fish catches. Fishing activities have provided great economic benefits for local communities. The industrial tuna fishing is conducted by foreign vessels that have obtained fishing licenses in Malagasy waters. Longline and purse seiner are the main fishing gear used. Some of the purse seiners landed their catches at the port of Antsiranana.

Apart from the targeted tunas, byproducts which are composed by all non-targeted species, small or damaged targeted tuna species that are not accepted by the cannery are also landed. They are often neglected and are not recorded in the fishing charts but sold on the local market and constitute an important source of food for the local population. Frigate mackerel is one of the identified species sampled from the byproducts landed by purse seiners, and constitute 25% of the byproducts landed.

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). It is a highly migratory species ant often associated with others Scombridae. Understanding the biological characteristics are very important for analyzing the changing trend in fish populations and evaluating the level of fish being exploited.

This paper studies the growth parameters of frigate mackerel landed at the port of Antsiranana during the period 2012 – 2019. It is giving an update of the previous study in 2017, which 'sampling of Frigate tuna as byproducts of purse seiners at the port of Antsiranana – Madagascar.

2. MATERIALS AND METHODS

The data used in this paper are from the byproducts of the purse seiners landed at the port of Antsiranana from 2012 to 2019. In general, the catches are caught by the seiners in the Mozambique channel, in the waters north of Madagascar and east of Kenya and Somalia.

2.1 Sampling of byproducts

The methodology used is the same as the methodology detailed by RAHOMBANJANAHARY D. in 2012. It consists initially, to carry out sampling at landings and transshipments. In fact,

200 fishes among the byproducts are first identified and then measured in fork length (FL) by the field samplers per day and per boat. The collected information is immediately recorded in pre-established form. The objective of the sampling is to have an idea of the species composition of the byproducts and their size distribution.

Fork length were measured in centimeter, and randomly measured for all fish species. The length frequency data was pooled into groups with 1 cm length intervals for *Auxis thazard*.

The second step is to explore the information associated with the quantitative evaluation of the byproducts landed by each boat. For this, a suitable form was designed to follow the dockers' speed movement. Indeed, different packaging is used by the dockers to bring the byproducts outside the boat such as the net (estimated to contain 2500 kg of fish), the cages (either 1200 or 1400 kg), the package (35 kg), etc. These packaging are then counted to evaluate the amount of byproducts landed and locally marketed.

All information collected will be entered in a database waiting for treatment and the filled forms are classified as archives.

2.2 Growth Parameters

Fish growth parameters (K and L_∞) were estimated using subprogram ELEFAN 1 in LFDA5 software. Analysis based on fish length data was assessed using following growth formula Von Bertalanffy Growth Function (1938):

$$L_t = L_\infty(1 - e^{-K(t-t_0)})$$

Where :

- L_t : 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) was used:

$$\log_{10}(t_0) = -0,392 - 0,275.\log_{10}L_\infty - 1,038.\log_{10}K$$

2.3 Mortality rate

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

$$M = 0,8 \times \exp(-0,152 - 0,279 \times \ln L_\infty + 0,6543 \times \ln K + 0,463 \times \ln T)$$

Where :

- M : natural mortality ;
- L_∞ : asymptotic length ;
- K : growth coefficient ;
- T : average estimated temperature

Total mortality (Z) was estimated using the method of Jones and Van Zalinge (1981, in Sparre and Venema, 1996).

Measurement of both parameters indicated that fish mortality resulted from fishing activity (F), calculated as follows: F = Z – M

3. Results and discussion

3.1 Frigate mackerel (*Auxis thazard*) size frequency distribution landed by purse seiners

During the period 2012 to 2019, 105 seiners landed or transhipped in the port of Antsiranana; 97 of them (≈90%) catched the frigate tuna and allowed the sampling. This explains the abundance and distribution of the frigate mackerel in the North West of the Indian Ocean. The total of 18 997 individuals were sampled. All the samples were measured in fork length. The following figure shows the frequency distribution (LF in cm) of the *Auxis thazard* sampled at the port of Antsiranana from 2012 to 2019.
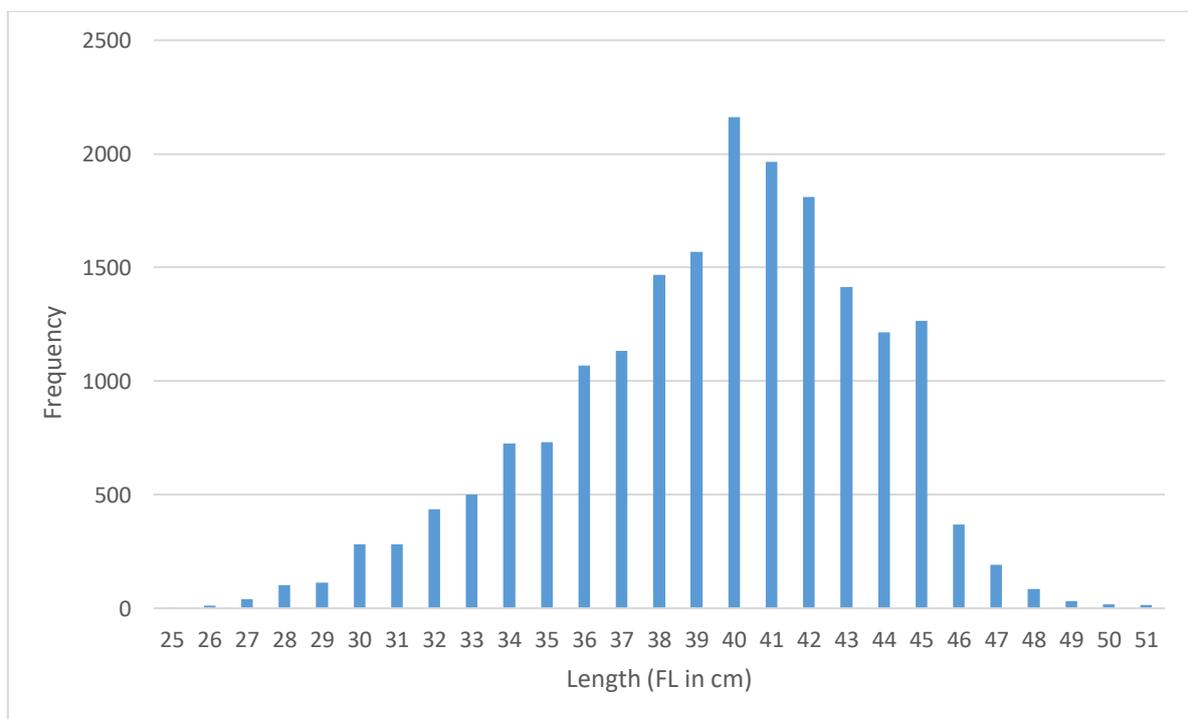
Figure 1: Length frequency distribution of *Auxis thazard* sampled at hte port of Antsiranana from 2012 to 2019 (n = 10 437)

The most captured individuals are having size between 36 cm and 45 cm while the pic is observed between 40 cm and 42 cm (**fig. 1**). Abussamad et *al.,* 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 found that length of frigate mackerel caught in the waters of North Andhra Pradesh, India was 30-46 cm. Robert et *al*., reported that frigate mackerel caught in the

waters of New Zealand had a length range of 26-41 cm. Tao et al., reported that the length of frigate mackerel in the Taiwan Strait was 25-40 cm.

However, in our case, the small and large individuals are fewer, this can be explained by natural mortality, or the notion of distribution; juveniles and adults would not occupy the same living area.

The average of size frequency estimated from the sample of *Auxis thazard* (2012-2019) is 39,50 cm. Tester and Nakamura (1957) reported that the maturity size of the *Auxis thazard* is 35 cm, while Yasui (1975) found the maturity size to 29 cm.

3.2 Von Bertalanffy equation

The calculation of the asymptotic length L_∞ and the growth rate K is estimated using the software LFDA 5, which uses the ELEFAN I program by the modal progression analysis. The parameters estimated are $L_\infty = 48.41$ cm and $K = 0.53$ year^{-1}. Using the empirical formula of Pauly, the theoretical age of frigate mackerel obtained is $t_0 = -0.071$.

The result indicated that the equation of *Auxis thazard* growth followed the curve Von Bertalanffy :

$$L_t = 48,41(1 - e^{-0,53\,(t-\,(-0,071))})$$

This equation enabled to describe a model curve of the relationship between fish age and fish length (**Figure 2**).
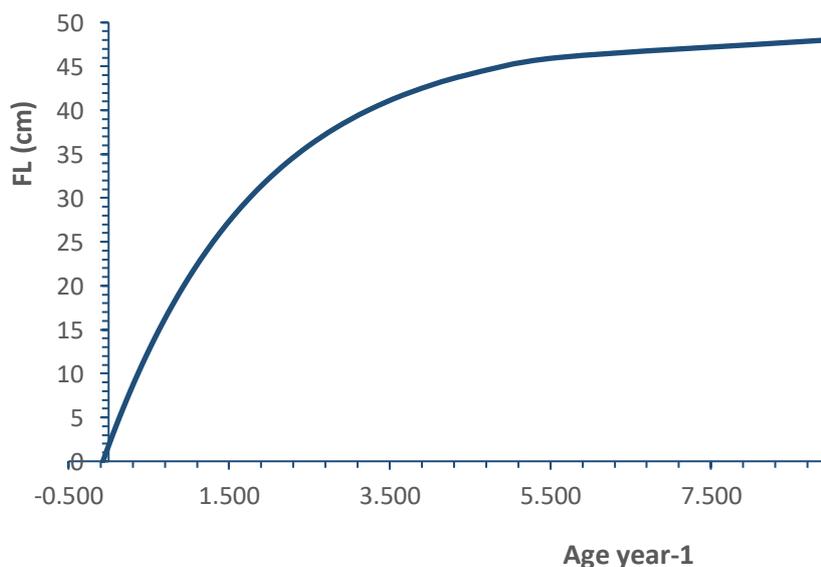
Figure 2 : Growth curve of *Auxis thazard* landed at the port of Antsiranana

The following table gives information on various growth parameters of Von Bertalanffy (L_∞, K, t_0) studied in the Indian Ocean, those resumed by IOTC in 2016 and from the present study (**Table 1**).

Table 1. Estimated growth parameters for frigate tuna (*Auxis thazard*) with details of type of analysis

Region	Von Bertalanffy growth parameters			Method	Aalysis type	Reference
	L∞	K/year	to			
Philippines	36,6	1,21	-0,12			Fishbase
Taïwan	48,2	0,52	-0,332	Vertebrae	Annual increments	(Yu et *al,* 2012)
Inde (Veraval)	46,6	0,93	-0,015	FL	ELEFAN	(Gosh et *al*, 2010)
Inde	57,9	1,2	-0,008	FL	ELEFAN	(Gosh et *al*,2012)
Inde (East Coast)	53,8	1,04		FL	ELEFAN	(Kasim & Abdussamad 2003)
Inde (Tuticorin)	49 (M)	1,3	-0,003	FL	ELEFAN	(Kasim, 2002)
	51.2 (F)	1,3	-0,004			
Indonésie	47,5	0,7		FL	ELEFAN	(Dwinpongo et *al*, 1986)
Sri Lanka	58	0,54		FL	ELEFAN	(Joseph et *al*, 1986)
Thaïlande (Golf)	52	1,4		FL	Progression Modal	(Yosaki, 1989)
Thaïlande (West Coast)	47,2	0,8		FL	Progression Modal	(Yosaki, 1982)
Philippines	47	0,73		FL	ELEFAN	(Ingles & Pauly 1985)
Madagascar	48,41	0,53	-0,071	FL	ELEFAN	Present study

The estimated value for K = 0.53 is very closed to the value found by Yu et *al*, 2012 and Joseph et *al*, 1986. But it is smaller than the estimated value by Ghosh et *al*, 2010, 2012; Kasim and Abdumassad, 2003; Kasim, 2002; Dwinpongo et *al*, 1986; Yosaki, 1982, 1989; and the one found by Ingles and Pauly, 1985.

As for the asymptotic length L∞: 48.41 cm (LF) found, it is closed by that calculated by Yu et *al*, 2012; Dwinpongo et *al*, 1986; Yosaki, 1982 and Ingles and Pauly, 1985. On the other hand, it is lower than that estimated by Ghosh et *al*, 2010; Kasim and Abdumassad, 2003; Kasim, 2002; Joseph et *al*, 1986; and Yosaki, 1989; but it's larger than Fishbase.

3.3 Mortality characteristics

The results obtained using the method of Jones and Van Zalinge (1981) demonstrated the total mortality **Z** of **0.95 years^{-1};** natural mortality **M** estimated by the formula of Pauly (1980) of **0.71 years^{-1};** fishing mortality **F** of **0.24 years^{-1}**. The following table (**table** 2) resumed some parameters mortality obtained by different authors. Whatever the method used, the estimated values are entirely dependent on the choice of points used for the calculation of the modal regression.

Table 2. Mortality parameters of different authors

Z	M	F	Reference
1.14	0.9	0.21	Lu et al, 1991
1.31	0.91	0.31	Yu Tao et *al,* 2012
5.97	1.48	4.48	Ghosh et *al,* 2010
0.95	0.71	0.24	Present study

The values of Z and M estimated are closed to that obtained by Lu et *al*, 1991, but lower than that of Yu Tao et *al*, 2010 and Ghosh et *al*, 2010. But the value of F is less than the values estimated by Yu Tao et *al*, 2010 and Ghosh et *al*, 2010 and is closed to that the values obtained by Lu et *al*, 1991.

4. Conclusion

During the period of investigation (from 2012 to 2019), the Frigate tuna landed at the port of Antsiranana had a wide length range of 25-51 cm, generally dominated by sizes between 40 cm and 42 cm. The average of size frequency estimated is **39,50 cm**. On the basis of data of 18,997 individuals collected, we are able to estimate the growth parameters of this species. Asymptotic length **L∞** of frigate tuna was **48.41 cm** with a growth rate **K** of **0.53 year^{-1}** and the growth rate when the specimen was at zero length (**t$_0$**) of -**0.071 year^{-1}**. The total mortality rate (**Z**) estimated for the frigate tuna, according to the model of Jones and Van Zalinge has been calculated as **0.95 year^{-1}**. The natural mortality **M** estimated by formula of Pauly was 0.71 **years^{-1}** while the fishing mortality **F** was **0.24 years^{-1}.**

This work has been limited to the study of the tuna-size frequency distributions, allowing us to have a general idea of the size structure of this species and an overview of its growth. Other studies are in progress, and with the new USTA laboratory, the biology and ecology of the species will be deepened.

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