Saudi Journal of Medical and Pharmaceutical Sciences **ISSN 2413-4929 (Print)**
Scholars Middle East Publishers **ISSN 2413-4910 (Online)**
Dubai, United Arab Emirates
Website: http://scholarsmepub.com/

Population Dynamics of Little Tunny (*Euthynnus alletteratus*, Rafinesque, 1810) exploited in the Gulf of Guinea, Ivory Coast

ANGUI Kouamé Jean Paul[2,*], DIAHA N'guessan Constance[1], ASSAN N'dri Florentine[2], EDOUKOU Abekan[2], N'GUESSAN Yao[2], GUILLOU Aurélie Marie[3], N'DA Konan[2]

[1]Laboratoire du Département Ressources Aquatiques Vivantes du Centre de Recherches Océanologiques – 29, Rue des Pêcheurs, BP V18 Abidjan, Côte d'Ivoire

[2]Laboratoire de Biologie et de Cytologie Animale de l'Université Nangui Abrogoua, 02 BP 801 Abidjan 02, Côte d'Ivoire

[3]Observatoire des Ecosystèmes Pélagiques Tropicaux exploités, UMR MARBEC 248, Institut de Recherche pour le Développement (IRD), CRO, Abidjan, Côte d'Ivoire

Original Research Article

***Corresponding author**
ANGUI Kouamé Jean Paul

Article History
Received: 12.03.2018
Accepted: 22.03.2018
Published: 28.03.2018

DOI:
10.21276/sjmps.2018.4.3.8

Abstract: The population structure, growth, mortality and exploitation status of *Euthynnus alletteratus* were examined in the Gulf of Guinea between January 2015 and December 2016. Monthly length frequency data of *Euthynnus alletteratus* were analyzed by FiSAT II software for estimation of population parameters which include asymptotic length (L_∞), specific growth level (K) and recruitment pattern to evaluate the status of the stock. Asymptotic length was 100.8 cm, and specific growth level was 0.07 yr^{-1}, value was too low, while the growth performance index was 2.85. Total mortality (Z) by length-converted catch curve was estimated at 0.82 yr^{-1}, fishing mortality (F) 0.61yr^{-1} and natural mortality (M) 0.21 yr^{-1}. The recruitment pattern was continuous all the year with two peaks of unequal importance: the secondary appears between March and April while the main is observed from July to August. The exploitation level (E) of *Euthynnus alletteratus* was 0.74 that on the maximum allowable limit of exploitation (Emax) which was 0.42. The exploitation level (E>0.50) indicates that the fishing pressure on *Euthynnus alletteratus* is very high. Thus the status of the stock in the Gulf of Guinea seems to be surexploited.

Keywords: Growth, Exploitation, Asymptotic length, Mortality, Recruitment.

INTRODUCTION

Euthynnus alletteratus Rafinesque in 1810 is a species of little tuna belonging to the family Scombridae. This species is present in the Atlantic Ocean, in tropical and subtropical waters, including the Mediterranean one, the Black Sea, the Caribbean Sea, the Gulf of Mexico, the Gulf of Guinea [1].

In Ivory Coast, little tunny is exploited mainly by artisanal boats with a significant seasonal difference of the landings. This species available during all the year is usually sold on the local market; so it constitutes one of principal provisioning source of population [2].

Many biological studies undertaken on the little tunny in the world relate to the reproduction diet, growth and population dynamics [3-15].

The work undertaken on this species in Ivory Coast was focused on diet and reproduction [16, 17]. On the other hand, the studies on the population dynamics and exploitation level of the little tunny in Ivory Coast fisheries are non-existent.

For the planning and the stock management of the little tunny, the knowledge of these population parameters is necessary.

The objective of this study is to appreciate the population parameters and exploitation level (E) of *Euthynnus alletteratus* to evaluate the inventory status report of this species.

MATERIALS AND METHODS

Sampling

Weekly samples of *Euthynnus alletteratus* were collected between January 2015 and December 2016 with the quay paddler of Zimbabwé (fishermen's village). The fish were captured using gill nets drifting along the littoral of the Ivory Coast (Figure-1). In laboratory fork length and total weight were recorded for each sample.

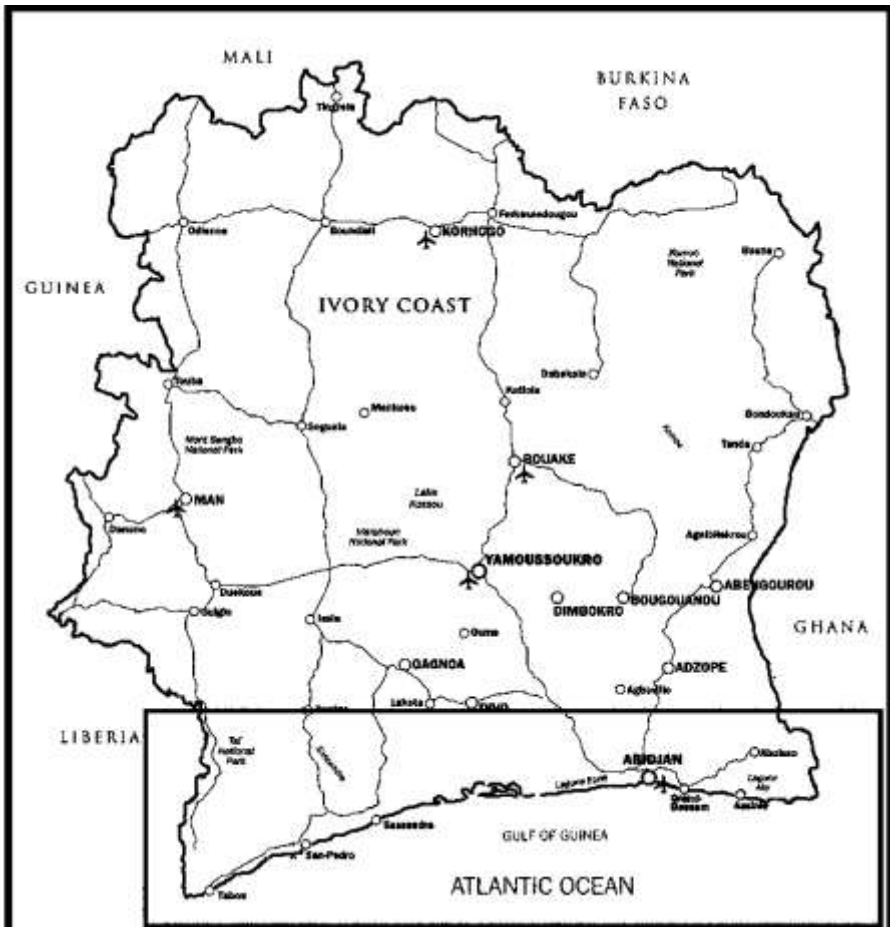

Fig-1: Artisanal fishing area (framed part)

Growth parameters

The weekly data were shared and consequently gathered in length class with 1 cm of interval, then analyzed by using the software FiSAT II [18]. Method consists in revealing the modes of the frequency distributions of size and validating the growth curves whose layouts, superimposed on those of the distributions themselves, take into account the greatest number of these modes. Distributions themselves and growth curves selected are then drawn on the same graph which illustrates thus method.

The study of the growth was made using Von Bertalanffy equation:

$$Lt = L_{\infty} (1 - e^{(-K (t-to))})$$

Where,

Lt is length (FL) at age t considered (days, month or year);

L_{∞} is theoretical maximum length or asymptotic length. This parameter is considered as being the length of an infinitely old fish. However, since the length is defined as being the average length of the troop (group of age), we will consider that L_{∞} is the average size of infinitely old fish or, older fish [19];

K is the specific growth rate characterizing the speed with which the species believes towards its asymptotic size;

To is the theoretical age at zero length.

The asymptotic length (L_∞) and the specific growth rate (K) of Von Bertalanffy was estimated by means of method ELEFAN I [20]. According to these authors, the choice of this method is dictated by the fact that it is less subjective than the method of Shepherd and that of Powell-Wetherall, in the sense that it makes it possible to obtain reliable information. It uses the size frequencies collected on different dates and for each couple of data (size, frequency), an age corresponding is calculated in order to determine the size ad infinitum (L_∞) and the specific growth rate (K). The reliability of these growth parameters was tested by applying the test phiwhere the index of growth performance (φ') calculated according to the method of Pauly and Munro [21]:

$$\varphi' = \log10K + 2x\log10L\infty.$$

The φ′ value is between 2.65 and 3.32 for the majority of African fish [22].

The determination of to was made by using the empirical equation of Pauly [23] which is formulated as follows:

$$\log10 (-to) = -0.392 - 0.275x\log10\ L\infty - 1.038\log10K.$$

Size of first capture

It represents the size for which 50% of fish are retained by the fishing gear. L_{50} is called, by estimate, the size with the first capture (Lc). It corresponds to the average length of selection because it was considered that this selectivity is symmetrical, i.e. 50% of the fish which enter the gill net escape through the meshes and 50% are retained [24]. It was estimated as a component of the curve length of linearized capture.

Estimate of mortality

Total mortality (Z) (setof all mortalities) was evaluated by the method known as "of the curves of captures according to lengths' converted" through the formula Ln (Ni/dti). Ni represents the number of individual in the class of size i and dt is the time put by fish to grow in this class i. This formula, development and exposed by Pauly [25, 21, 24] and Pauly *et al*., [26], is implemented in software FiSAT II.

Natural mortality (M) (mortality due to the various factors other than fishing) as for it rises from the empirical relation of Pauly [27]:

$$\text{Log10M} = -0.0066 - 0.279 \text{ x Log10 } L\infty + 0.6543 \text{ x Log10K} + 0.4634 \text{ x Log10T}$$

Where,

M represents natural mortality; L_∞ the asymptotic length; K the specific growth rate; T the annual average temperature of habitat (c).

Mortality by fishing (F) (mortality only caused by the effects of fishing) was evaluated after obtaining Z and M by using the relation:

$$F = Z - M.$$

Estimate of the exploitation level

The exploitation level (E) represents the proportion of the population exploited compared to the whole population. When one has the values of F and M, an exploitation level (E) can be calculated by the equation [28]:

$$E = F/Z = F/(F + M).$$

This equation makes it possible to judge inventory position. If E is equal to 0.5, the exploitation of stock is normal; if E is lower than 0.5, stock is underexploited, and if E is higher than 0.5, stock is overexploited [29].

Recruitment rate

Recruitment is defined as the process by which the young people integrate for the first time an adult stock and thus become accessible to the fishermen [30]. The recruitment model is obtained by projecting the data of length frequency behind on the axis time by using the growth parameters [31]. The normal distribution of the recruitment model was determined by NORMSEP in FiSAT II [26].

RESULTS

Growth parameters

The analysis related to a total of 1093 specimens of *Euthynnus alletteratus* measured. Values asymptotic length (L_∞) and the growth specific rate (K) of Von Bertalanffy equation determined using the ELEFAN-I program are 100.8 cm and 0.07 year^{-1} respectively. The growth performance index (φ') found is 2.85 while it is estimated at -1.29. By using these parameters, the growth model of Von Bertalanffy is described in the following way:

$$L_t = 100.8[1-e^{-0.07(t+1.29)}].$$

The population parameters are presented in Table-1.

Table-1: Population parameters of *Euthynnus alletteratus* in the Gulf of Guinea

Population parameters	Value
Asymptotic length (L_∞) in cm	100.80
Growth rate (K) in yr^{-1}	0.070
Hypothetic age (t_o) in yr	-1.29
Growth performance index (φ')	2.85
Natural mortality (M) in yr^{-1}	0.21
Fishing mortality (F) in yr^{-1}	0.61
Total mortality (Z) in yr^{-1}	0.82
Exploitation rate (E)	0.74
Limit of maximum exploitation (Emax)	0.42
Size of first capture (Lc) in cm	40.34
Interval of exploited size in cm	32-96
Number of fish (N)	1093

Figure-2 indicates the distributions of the size frequency histograms for *Euthynnus alletteratus* resulting from FiSAT. The fork length of fish captured varies from 32 to 96 cm whereas the sizes significantly exploited by artisanal fishing are between 40 and 52 cm. The biggest fish sizes were recorded in June.

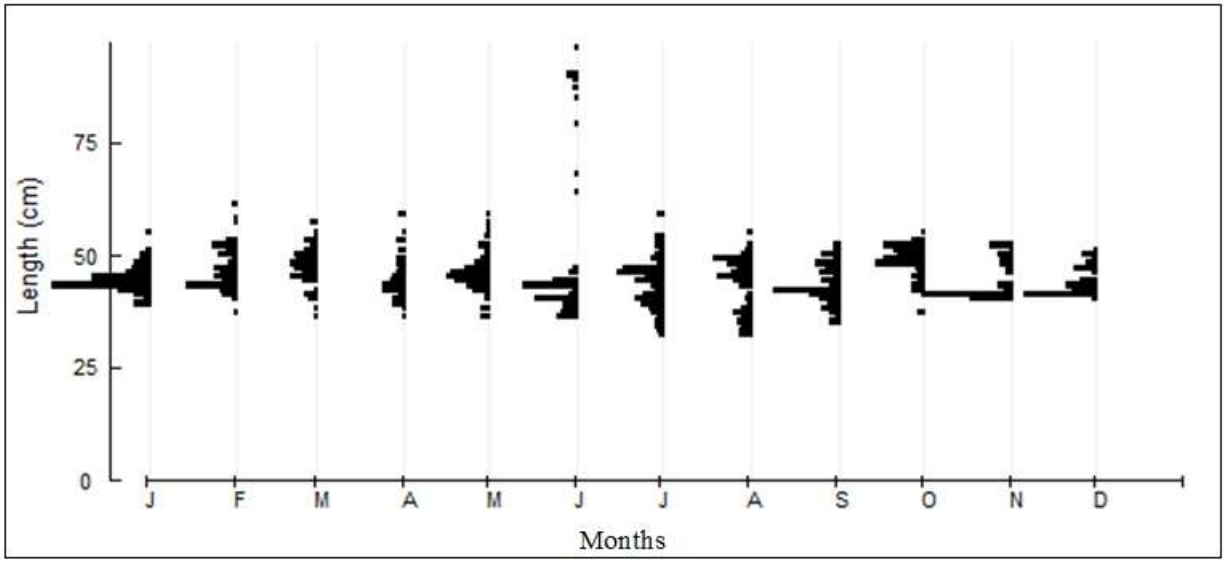

Fig-2: Distribution of size frequency histograms at *Euthynnus alletteratus* resulting from FiSAT

Size of first capture

The value of first capture obtained at *Euthynnus alletteratus* is 40.34 cm. The selection curve indicating the sizes corresponding to the captures probabilities to 25 %, 50% and 75 % is represented by figure-3.

The sizes with which 25 %, to 50% and 75 % of fish are captured are respectively 39.24 cm, 40.34 cm and 41.43 cm.

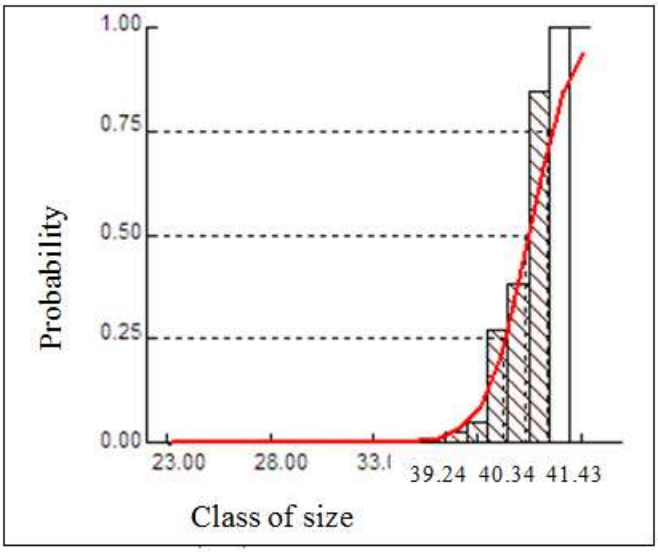

Fig-3: First capture (L_{50}) curve of *Euthynnus alletteratus* in the Gulf of Guinea

Estimate of mortality and exploitation rate

The capture curve of *Euthynnus alletteratus* is represented by figure-4. It indicates that total mortality (Z), natural mortality (M) and fishing mortality (F) of *E. alletteratus* estimated are respectively 0.82 $year^{-1}$, 0.21 $year^{-1}$, 0.61 $year^{-1}$ in the Gulf of Guinea. These results show a fishing mortality rate superior with natural mortality.

The exploitation rate (E) was 0.74. It is higher than the breaking value which is 0.5. *Euthynnus alletteratus* is thus an overexploited species (Table-1).

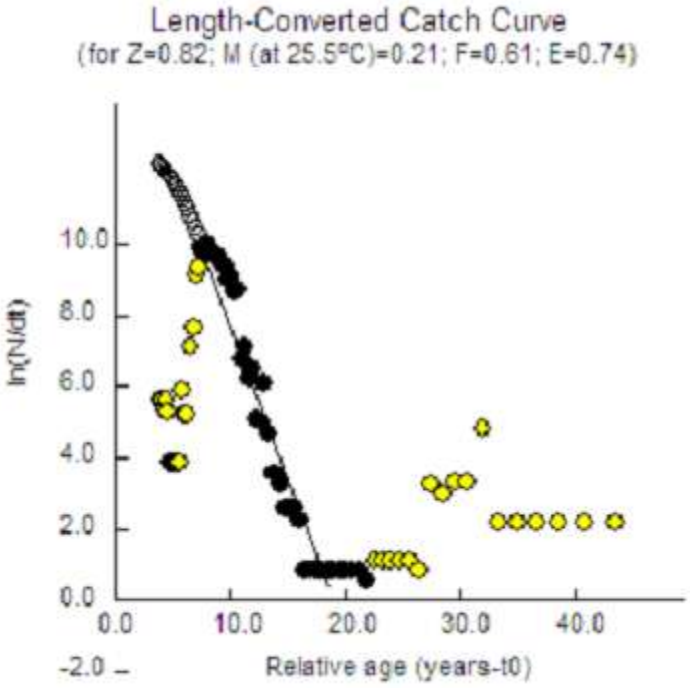

Fig-4: Length converted catch curve of *Euthynnus alletteratus*. Z = total mortality, M = natural mortality, F= fishing mortality, E = exploitation rate

Recruitment model

The monthly recruitment rate of *Euthynnus alletteratus* is illustrated by figure 5. The histograms are smoothed by two curves of Gauss in order to allow a better visualization of the peaks. The recruitment estimated for this species is continuous all the year with two recruitment peaks of unequal importance. Thus the maximum of recruitment takes place from July to August and borders the 20%. The second peak is observed in March and exceeds 10%.

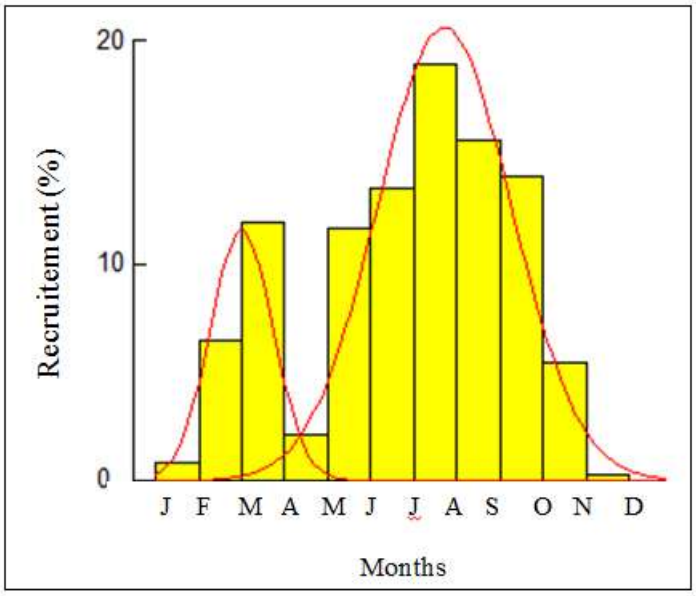

Fig-5: Recruitment model of *Euthynnus alletteratus* in Gulf of Guinea fishing stock

DISCUSSION

The estimated asymptotic length ($L\infty$ = 100.8 cm) reported in this study was included between that found in Spain (91.5 cm) [14] and Egypt (123.4 cm) [15]. On the other hand, our K value (0.07 $year^{-1}$) was lower than both values reported in the literature for populations in Eastern Coast of Mediterranean Sea off Alexandria, Egypt (K = 0.16 $year^{-1}$) [15] and Western Mediterranean Sea (K = 0.390 $year^{-1}$) in Spain [14]. Differences in Von Bertalanffy growth parameters for these different studies may be attributed to temporal and geographical variations. Fish populations of the same species from different geographical regions may exhibit highly variable, individual growth rates [32]. The differences may be due to the differences in stock population emanating from genetic factors, environmental variables of their aquatic habitat [33], nutrient availability or population dependent factors of the particular geographical location [34]. The growth parameters estimated by means of FiSAT software are biologically reasonable. Indeed, the growth performance index (φ' = 2.85) of *Euthynnus alletteratus* based over the fork length is not significantly different from those estimated for the majority of African fish ranging between 2.65 and 3.32 [35]. However, although $L\infty$ and K are not specific to the species, the φ' value obtained in this study is included in the interval of the values recommended by these authors, which means that the growth rate of *Euthynnus alletteratus* in the Gulf of Guinea is average. This average growth rate could be due to the water temperature. Indeed, several authors showed that the temperature is the most significant factor which limits the fish growth [36].

The size of the first capture in Ivory Coast is estimated at 40.34 cm. It is lower than the size of the first maturity (43 cm). The current level of Lc should be high, at least with 43cm, to make it possible fish to generate at least once during their life and to increase the biomass. For this reason, in Turkey, the law prohibits the capture of *Euthynnus alletteratus* of less than 45 cm because maturity settles starting from 45 cm [37].

Gulland [38] suggested that in an optimally exploited stock, fishing mortality (F) should be equal to natural mortality (M), resulting in an exploitation ratio of 0.5. In this study, the fishing mortality (F = 0.61 $year^{-1}$) compared to natural mortality (M = 0.21 $year^{-1}$) indicates the unbalanced position of the little tunny stock in the Gulf of Guinea. This can be due to the fact of fishing pressure. The maximum exploitation rate (Emax), which gives maximum relative yield per recruit, is estimated at 0.42 and differs from the exploitation rate (0.74) estimated in this study. This value is higher at the maximum exploitation rate established for *Euthynnus alletteratus*, suggesting that the stock is overexploited.

This study elucidates that the recruitment pattern of *Euthynnus alletteratus* is continuous with two recruitment peaks; one major and one minor recruitment peak per year. This is consistent with Pauly's [28] assertion of double recruitment pulses per year for tropical fish species and for short-lived species. There are no published reports on *Euthynnus alletteratus* recruitment in Ivory Coast. However, it has been reported that this species spawns mainly from May to October [17]. We think that the major recruitment peak (July-August) observed in this study corresponds to the former spawning season.

CONCLUSION

The present study reveals an overexploitation state of the stock of *Euthynnus alletteratus* in the Gulf of Guinea, Ivory Coast. It would be better to think of a management of these stocks in order to ensure their sustainability. Measurements of management should be taken with knowing control of the meshes of the nets, the increase in the size of first capture to at least 43 cm and the temporary closing of the fishing seasons for the spawning period.

REFERENCES

1. Collette, B., Acero, A., Amorim, A. F., Boustany, A., Canales Ramirez, C., Cardenas, G., ... & Chang, S. K. (2011). de Oliveira Leite Jr. *N., Di Natale, A., Die, D., Fox, W., Fredou, FL, Graves, J., Viera Hazin, FH, Hinton, M., Juan Jorda, M., Kada, O., Minte Vera, C., Miyabe, N., Nelson, R., Oxenford, H., Pollard, D., Restrepo, V., Schratwieser, J., Teixeira Lessa, RP, Pires Ferreira Travassos, PE & Uozumi, Y*.
2. Diaha, N. C., & N'da, K. (2009). Etude comparée de la pêche des thonidés mineurs par les chaluts doubles et les pirogues dans la zone économique exclusive (ZEE) ivoirienne. Tropicultura, 27 (3), 152-158.
3. Kahraman, A. E., & Oray, I. K. (2001). The determination of age and growth parameters of Atlantic little tunny (*Euthynnus alletteratus* Rafinesque, 1810) caught in Turkish waters. SCRS/00/49. Collective Volume of Scientific Papers ICCAT, 52: 719–732.
4. Macías, D., Lema, L., Gómez-Vives, M. J., Ortiz de Urbina, J. M., & de la Serna, J. M. (2006). Some biological aspects of small tunas (*Euthynnus alletteratus*, *Sarda sarda* & *Auxisrochei*) from the South Western Spanish Mediterranean traps. SCRS/2005/103. Collective Volume of Scientific Papers ICCAT, 59(2), 579-589.
5. Kahraman, A. E. (2005). Preliminary investigations on Atlantic little tunny (*Euthynnus alletteratus* Rafinesque, 1810) in the eastern Mediterranean Sea. Collective Volume of Scientific Papers ICCAT, 58(2), 502–509.
6. Kahraman, A. E., & Alicli, T. Z. (2007). Sexual maturity of little tunny, *Euthynnus alletteratus*, in the North-Eastern Levantine Basin.Istanbul University, Fisheries Faculty, Laleli, Istanbul, Turkey. Rapp. Comm. int. Mer Médit., 38
7. Gaykov, V. Z., & Bokhanov, D. V. (2008). The biological characteristic of Atlantic black skipjack (*Euthynnus alletteratus*) of the eastern Atlantic ocean. SCRS/2007/132. Collective Volume of Scientific Papers ICCAT, 62(5), 1610-1628.
8. Kahraman, A. E., Alicli, T. Z., Akayli, T., & Oray, I. K. (2008). Reproductive biology of little tunny, *Euthynnus alletteratus* (Rafinesque, 1810), from the north-eastern Mediterranean Sea. Journal Applied of Ichthyology, 24: 551-554.
9. Hajjej, G., Hattour, A., Allaya, H., Jarboui, O. & Bouain, A. (2009). Sex-ratio, relation taille-masse et coefficient de condition de la thonine commune *Euthynnus alletteratus* (Rafinesque, 1810) des côtes tunisiennes. Bulletin de l'Institut National des Sciences et Technologie de la Mer, 36: 39-44.
10. Valeiras, L., & Abad, E. (2010). Biologie de la reproduction d'*Euthynnus alletteratus*. In: MannuelICCAT, Commission Internationale pour la Conservation des Thonidés de l'Atlantique 1iè Édition (janvier 2010), Chapitre 2.1.10.5. Thonine, 244-251.
11. Faulatano, M., Castriota, L., Grazia, M., & Andaloro, F. (2007). Feeding ecology of little tunny *Euthynnus alletteratus* in the central Mediterranean Sea. Journal of the Marine Biological Association of the United Kingdom, 87: 999-1005.
12. Hajjej, G., Hattour, A., Allaya, H., Jarboui, O., Mourad, C., & Bouain, A. (2011). Biometry, Length-length and Length-weight relationships of little tunny *Euthynnus alletteratus* in the Tunisian Waters. Journal of Fisheries and Aquatic Science, 6(3), 256-263.
13. Santamaria, N., Deflorio, M., & De Metrio, G. (2005). Preliminary study on age and growth of juveniles of *sardasarda*, bloch, and *Euthynnus alletteratus*, rafinesque, caught by clupeoids purse seine in the southern Italian SEAS.SCRS/2004/087. Collective Volume of Scientific Papers ICCAT, 58(2), 630-643.
14. Valeiras, X., & Macías, D. (2008). Age and growth of Atlantic little tuna (*Euthynnus alletteratus*) in the western Mediterranean sea. Collective Volume of Scientific Papers ICCAT, 62(5), 1638-1648.
15. Elhaweet, A., Sabry, E., & Mohamed, H. (2013). Fishery and Population Characteristics of *Euthynnus alletteratus* (Rafinesque 1810) in the Eastern Coast of Alexandria, Egypt. Turkish Journal of Fisheries Aquatic Sciences, 13: 629-639.
16. Bahou, L., Koné, T., N'Douba, V., N'Guessan, K. J., Kouamelan, E. P., & Gouli, G. B. (2007). Food composition and feeding habits of little tunny (*Euthynnus alletteratus*) in continental shelf waters of Côte d'Ivoire (West Africa). ICES Journal of Marine Science, 64: 1044-1052.
17. Bahou, L., d'Almeida, M. A., Koné, T., Boua, C. A., & Séripka, G. D. (2016). Reproductive biology and histological characteristics of female little tunny *Euthynnus alletteratus* (Rafinesque, 1810) caught on continental shelf of Côte d'Ivoire. Scientific Journal of Biological Sciences, 5(1), 88-102.
18. Gayanilo, Jr. F. C., Sparre, P., & Pauly, D. (1996). FAO-ICLARM stock assessment tools (FISAT) User's Guide. FAO Computerized Information Series (Fisheries), 8, 126.
19. Kacher, M. (2004). Le merlu du golfe de Gascogne et de la mer celtique : croissance, répartition spatiale et bathymétrique, écologie alimentaire et assemblages. Thèse de Doctorat, Université Littoral - Côte d'Opale, 200 pp.

20. Pauly, D., & David, N. (1987). ELEFAN I, a BASIC program for the objective extraction of growth parameters from length-frequency data. Meeresforsch, 28 (4), 205-211.
21. Pauly, D., & Munro, J. L. (1984). Once more on the comparison of growth in fish and invertebrates. Fishbyte, 2, 21-22.
22. Baijot, E., & Moreau, J. (1997). Biology and demographic status of the main fish species in the reservoirs of Burkina Faso. In: Hydrological aspects of fisheries in small reservoirs in the Sahel Region.
23. Pauly, D. (1979). Theory and management of tropical multispecies stocks: a review with emphasis on the Southeast Asian demersal fisheries. ICLARM Studies Review, 1, 35 pp.
24. Pauly, D. (1990). Length-converted catch curves and the seasonal growth of fishes. Fishbyte, 8, 33-38.
25. Pauly, D. (1983). Length-converted catch curve: a powerful tool for fisheries research in the tropics (Part I). Fishbyte, 1(2), 9-13.
26. Pauly, D., & Caddy, J. F. (1985). A modification of Bhattacharya's method for the analysis of mixtures of normal distributions. FAO, Rome, FAO Fisheries Circular, (781): 16p.
27. Pauly, D. (1980). On the interrelationship between natural mortality, growth parameters and mean environmental temperature in 175 fish stock. Journal of CIEM, 39 (3), 175-192.
28. Pauly, D. (1982). Une sélection de méthodes simples pour l'estimation des stocks de poissons tropicaux. FAO, Fisheries Circular, (729): 63 pp.
29. Gulland, J. A. (1969). Manuel des méthodes d'évaluation des stocks d'animaux aquatiques. Première partie. Analyse des populations. FAO, Manuel de Science Halieutique, 4: 160 p.
30. Flaman, J. M., Frebourg, T., Moreau, V., Charbonnier, F., Martin, C., Chappuis, P., ... & Benhattar, J. (1995). A simple p53 functional assay for screening cell lines, blood, and tumors. *Proceedings of the National Academy of Sciences*, *92*(9), 3963-3967.
31. Moreau, J., & Cuende, F. X. (1991). On improving the resolution of the recruitment patterns of fishes. ICLARM Fishbyte, 9: 45-46.
32. Wootton, R. J. (1998). Ecology of teleost fishes. 2nd edition. Kluwer Academic Publisher, London, 386 pp.
33. Odo, G. E., & Inyang, N. M. (2001). Growth, feed utilization and survival of African Catfish, Clarias gariepinus (Burhill, 1822). Fingerlings reared in tanks at different salinity levels. Journal of Aquatic Sciences, 16: 127-131.
34. Francis, A., & Sikoki, F. D. (2007). Growth coefficient of fish species within the Andoni River, Niger Delta, Nigeria and their aquaculture implications. Journal of Fisheries International, 2(1), 22-26.
35. Baijot, E., Moreau, J., Barry, I., & Bouda, S. (1997). Biology and Demography of the main Fish Species of Reservoirs in Burkina Faso. *Hydrobiological Aspects of Fisheries in Small Reservoirs in the Sahel Region, Baijot, E., J. Moreau and S. Bouda (Eds.). Technical Centre for Agricultural and Rural Cooperation, Wagenigen, Netherlands, ISBN, 700876790*, 140-141.
36. King R. P., & Etim, L. (2004). Reproduction, growth, mortality and yield of *Tilapia mariae* Boulenger, 1899 (Cichlidae) in Nigerian rain forest Westland stream. Journal of Applied Ichthyology, 20: 502-510.
37. Zengin, M., & Karakulak, F. S. (2009). Preliminary study on the Atlantic black skipjack (*Euthynnus alletteratus*, Rafinesque, 1810), caught by common purse seine fisheries in the north-eastern Mediterranean coast of Turkey. Collective Volume of Scientific Papers ICCAT, 64(7), 2211-2220.
38. Gulland, J. A. (1971). Science and fishery management. *ICES Journal of Marine Science*, *33*(3), 471-477.