



Validation of a growth estimation method: Application to the flathead mullet, *Mugil cephalus* in the Northern coast of Senegal

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ABSTRACT

Growth parameters estimation (L_{inf} and K) of *Mugil cephalus* in the Northern coast of Senegal was made with the 'ELEFAN in R' program, based on biological sampling carried out on three landing sites (Kayar, Fass Boye, Saint-Louis) in the Northern coast of Senegal at sea and on the Senegal River in 2011. The results obtained were 58.8 cm FL for asymptotic length and 0.32 years^{-1} for the growth coefficient of the Von Bertalanffy equation. The total mortality (Z) of juveniles was higher than that of adults of the species. L_{inf} and K values were closed to those estimated in the literature, confirming the relevance of the use of the 'ELEFAN in R' Model in the estimation of growth parameters of the Von Bertalanffy equation.

Indexing terms/Keywords

ELEFAN software, Growth estimation, *Mugil cephalus*, Senegal.

Academic Discipline And Sub-Disciplines

Biology

SUBJECT CLASSIFICATION

Fish biology

TYPE (METHOD/APPROACH)

Field survey, Biological sampling

1. INTRODUCTION

The Mugilidae (or grey mullets) is a speciose family of teleostean fishes. It includes 62 species belonging to 14 genera [14]. Representatives of this family are distributed in various coastal aquatic habitats of the world's tropical, subtropical and temperate regions [14]; [6]. Along the West coast of Africa, between Senegal and Angola, 10 species including flathead grey mullet *Mugil cephalus* are currently registered [1]; [15]; [9]; [10].

With a robust body, cylindrical slightly laterally compressed, with a large head and a yellow caudal fin [1] the flathead grey mullet is a migratory species [3]. *M. cephalus* feeds on zooplankton, benthic organisms and detritus [5]; [12]. Spawning occurs at sea and varies according to geographical location [4].

The flathead grey mullet, targeted by artisanal fisheries is caught on the Northern coast of Senegal. The fishing effort of gear that provides the bulk of the landings of the species (drift nets surface) has increased during the 2000s in this area. Due to the ecological and economic importance of *M. cephalus* [13], information on the life history traits of the species are available in some parts of the world [18].

However, recent information on life history traits of the species, are rare in Senegal. Indeed, in the current context of resources and fishery management in Senegal, updating knowledge on the biology of grey mullet, given its economic importance, is fundamental. The present work aimed to study the growth of grey mullet *M. cephalus* in the Northern coast of Senegal fits perfectly into this dynamic.

2. MATERIAL AND METHODS

The length-frequency data used, were from biological sampling carried out on three landing sites (Kayar, Fass Boye, Saint Louis) on the Northern coast of Senegal (Figure 1) at sea and on the Senegal River in 2011 (June, August, October, November, December). The choice of these months can be explained partly by the fact that they cover the abundance periods of the species in the area and on the other hand, by the fact that the presence of the species in the study area was very seasonal, which also explained the lack of data for some months. The sample consisted of 172 individuals caught at sea, with a size between 19.2 cm and 56.0 cm and 503 individuals from the River, varying in size from 13.5 cm to 55.2 cm (Table 1).



Table 1. Size distribution of specimens of *Mugil cephalus* collected in the Senegal River and in the sea in the Northern coast of Senegal in 2011.

Lower and upper size class limits (cm)	Midrange of size classes	Senegal River						Sea					TOTAL		
								Total						Total	
		June	August	October	November	December		June	August	October	November	December			
13-16	15.0	-	-	6	-	-	6	-	-	-	-	-	-	-	6
16-19	17.7	-	64	33	8	-	105	-	-	-	-	-	-	-	105
19-22	20.3	1	39	48	98	-	186	-	26	-	-	-	-	26	212
22-25	23.3	27	1	4	54	15	101	-	13	3	-	-	-	16	117
25-28	26.2	8	-	-	6	34	48	-	2	-	-	-	-	2	50
28-31	29.0	3	-	-	4	23	30	4	8	-	-	-	-	12	42
31-34	31.9	2	-	-	4	10	16	5	-	1	-	-	1	7	23
34-37	35.5	3	-	-	-	-	3	3	-	-	-	-	1	4	7
37-40	38.0	-	-	-	-	-	-	7	-	-	-	4	4	15	15
40-43	40.8	1	-	-	-	-	1	3	-	-	-	13	7	23	24
43-46	44.4	2	-	-	-	-	2	4	-	-	-	4	19	27	29
46-49	47.3	-	-	-	-	-	-	-	-	-	-	6	15	21	21
49-52	50.0	1	-	-	2	-	3	2	-	-	-	2	8	12	15
52-55	52.9	1	-	-	-	-	1	3	-	-	-	-	2	5	6
55-58	55.4	-	-	1	-	-	1	2	-	-	-	-	-	2	3
Total		49	104	92	176	82	503	33	49	4	29	57	172	675	



The ELEFAN program of Pauly [11] was applied to the pooled length-frequency data to estimate the parameters *Linf* and *K* of the Von Bertalanffy growth equation. Pauly [11] showed how, from a given set of frequency data and estimates of *Linf* and *K*, an estimate of instantaneous rate of total mortality can be obtained from a “length-converted catch curve”.

Total mortality (*Z*) is determined as followed:

$$N_t = N_0 e^{-Zt} \quad (1)$$

Where, *N*₀ and *N*_{*t*} are numbers of specimens at the beginning and end, respectively, of a time period *t*. A “length-converted catch curve” is obtained by summing up available size-frequency data over a certain period of time to smooth out the effect of recruitment pulses and small sample sizes. An estimate of *Z* can thus be obtained, based on the right-hand, fully selected side of a catch curve and under the assumption of a steady state (growth, mortality and recruitment constant) from:

$$\log_e(N_i/\Delta t_i) = a - Z \cdot t_i' \quad (2)$$

Where *N*_{*i*} is the number of specimens in a given size class (*i*), Δt_i is the time needed to grow through size class (*i*) and *t*_{*i*}' is the relative age corresponding to the midrange of size class (*i*). *Z* is estimated as the slope (with sign changed) of a linear regression of the form *y*=*a*+*b**x*, where $\log_e(N_i/\Delta t_i)$ =*y* and *t*_{*i*}'=*x*, while the values of *t*_{*i*}' and Δt_i are estimated from:

$$t_i' = \frac{-\log_e(1 - \frac{L}{L_\infty})}{K} \quad (3)$$

and

$$\Delta t_i = \frac{\ln(\frac{L_\infty - L_1}{L_\infty - L_2})}{K} \quad (4)$$

Where *L*₁ and *L*₂ correspond to the lower and upper size limits of class, respectively.

3. RESULTS

3.1. Size-frequency (L/F) by ELEFAN in R

Figure 1 shows plots of the size-frequency samples sequentially arranged in time, with growth curve fitted by ELEFAN program. This graph shows that the birth of individuals of the species occurs in December.

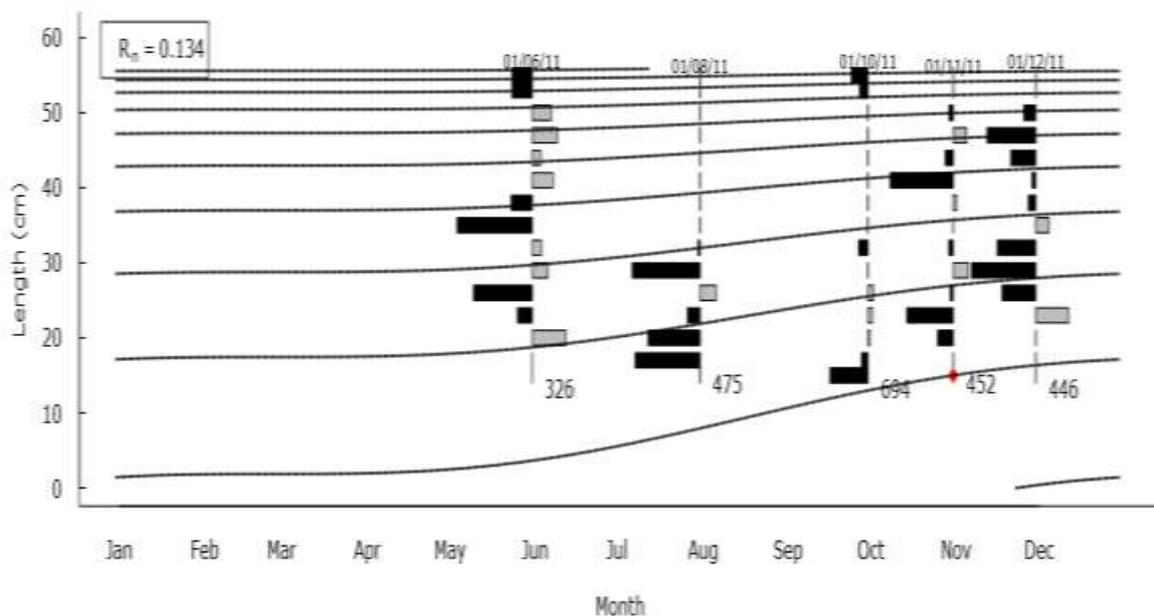


Figure 1. Size-frequency data for *Mugil cephalus*, with super imposed growth curves estimate by ELEFAN method, in the Northern coast of Senegal in 2011.

3.2. Estimated *Linf* by Wetherall plot and *K*

The growth parameters values estimated by the ELEFAN program were 58.8 cm FL for asymptotic length (*Linf*) and 0.32 year⁻¹ for the growth coefficient of Von Bertalanffy *K* (Figures 2 and 3).

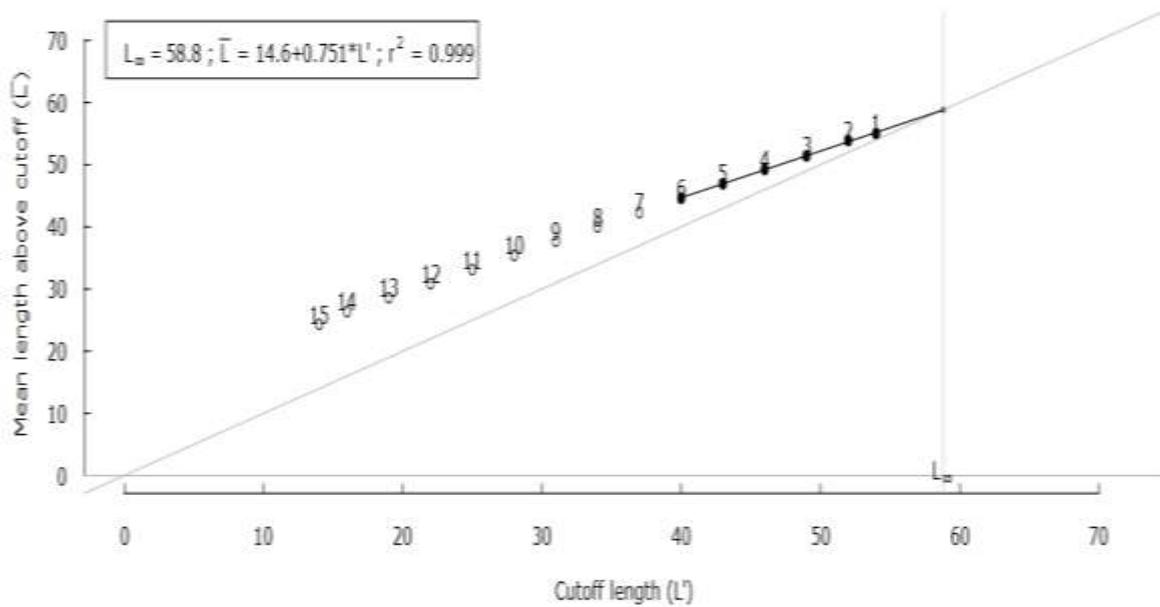


Figure 2. Asymptotic length of *Mugil cephalus* estimated by the ELEFAN program in the Northern coast of Senegal in 2011.

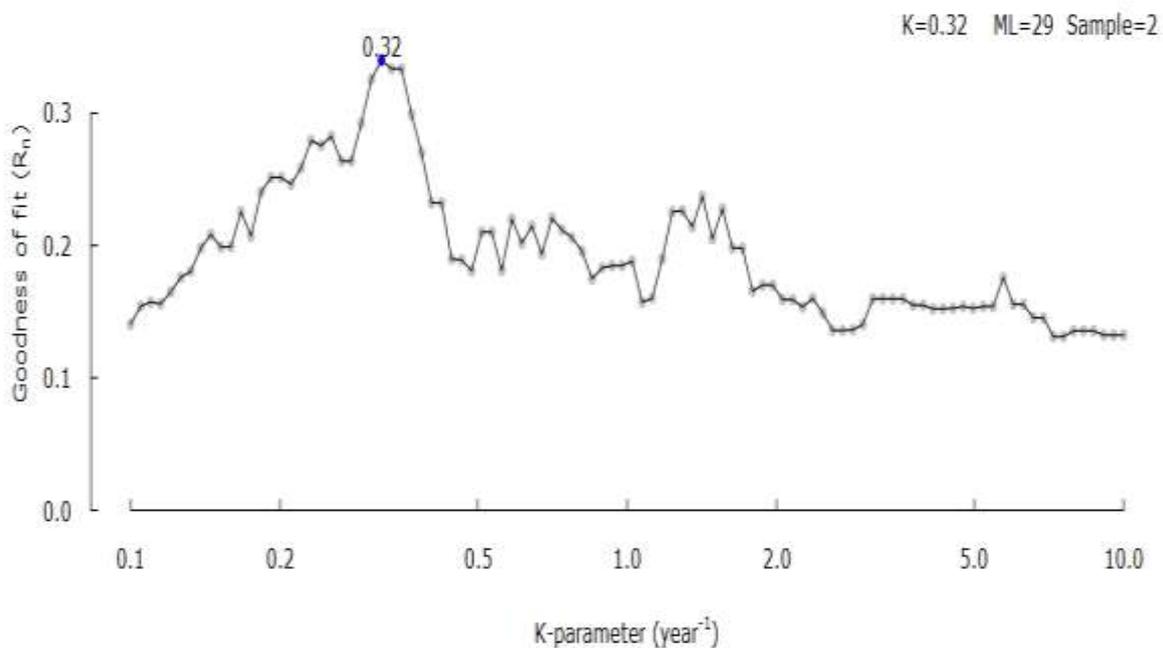


Figure 3. Growth coefficient of *Mugil cephalus* estimated by the ELEFAN program in the Northern coast of Senegal in 2011.

The growth curve of *Mugil cephalus* plotted from growth parameters data showed a fast growing during the first three years. Then the growth in length became very slow despite the increase in age of individuals (Figure 4).

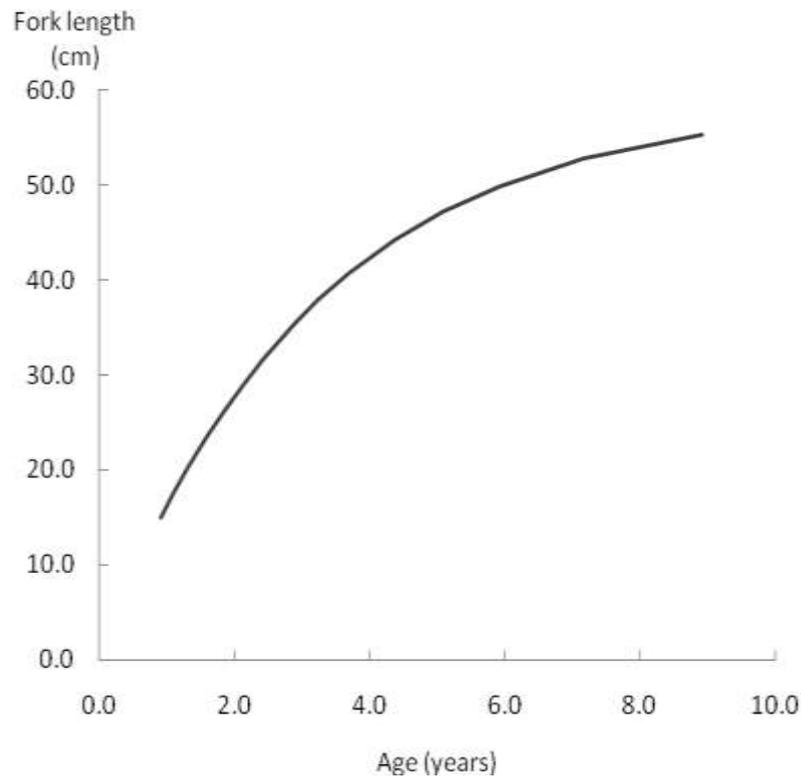


Figure 4. Growth curve of *Mugil cephalus* in the Northern coast of Senegal in 2011 ($L_{inf} = 58.8$ cm FL and $K = 0.32$ years⁻¹).

3.3. Catch curves

Catch curve clearly differentiates catches at sea to those made in the River. The latter were mostly small individuals. In contrast, individuals caught at sea were mostly large sizes. It appears that the mortality of juveniles was higher than those of adults. Indeed, the slope of the catch which is an estimate of the instantaneous mortality rate (Z) was higher for the juveniles catch curve ($a=8.8$ (Figure 6)) than for adults catch curve ($a=7.88$ (Figure 5)).

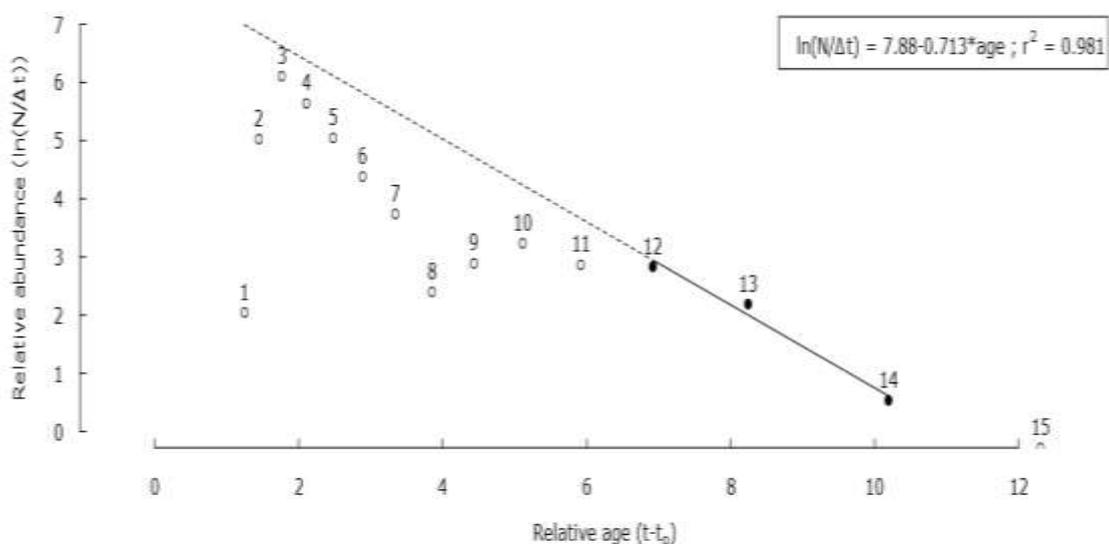


Figure 5. Total mortality (Z) curve of adults of *Mugil cephalus* in the Northern coast of Senegal in 2011.

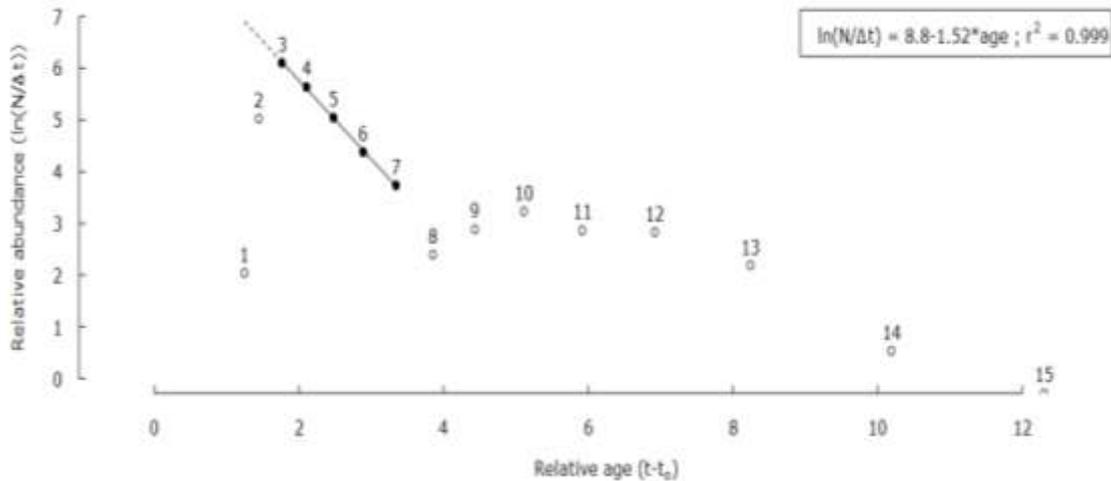


Figure 6. Total mortality (Z) curve of juveniles of *Mugil cephalus* in the Northern coast of Senegal in 2011.

4. DISCUSSION

The estimated *Linf* by ELEFAN program and the recalculated *Linf* in Fishbase (58.8 cm FL i.e. 66.0 cm TL) were compared to asymptotic size values available in Fishbase for approval. To this end, the asymptotic length estimated in fork length was converted to total length.

The *Linf* obtained was within the range of asymptotic sizes found in the literature (Fishbase, Figure 7). Indeed, the estimated *Linf* was close to that obtained in Tunisia: 69.3 cm TL by Farrugio [5]. It was also comparable to *Linf* values determined in other parts of the world. This was the case in Mexico (62.3 cm TL) by Ibañez-Aguirre et al. [7], in Australia (65.0 cm TL) by Kesteven [8] and in South Carolina (63.1 cm TL) by Vincent [17].

K and *Linf* fit perfectly within the range of values estimated for these two parameters in the literature. This validates the 'ELEFAN in R' model in the estimation of growth parameters of Von Bertalanffy (*Linf* and K) for the case of the flathead grey mullet *M. cephalus* in Senegal.

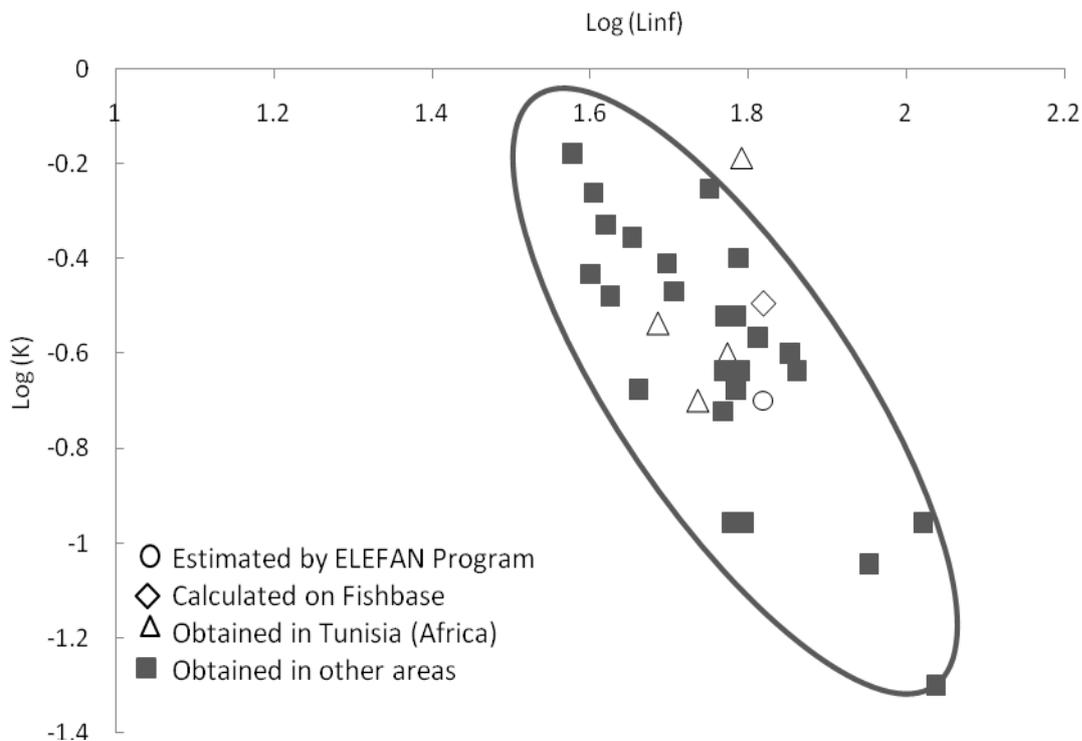


Figure 7. Log (K) and Log (*Linf*) relationship estimated in different areas



5. CONCLUSION

Finally, it appears that the application of 'ELEFAN in R' program on size frequency data of fish populations has led to comparable conclusions to those obtained in different studies that have used other methods. This method reinforces existing ones to estimate growth parameters and consequently represents an important additional tool for evaluating stocks in favour of sustainable management of resources and fisheries at a local and regional scale.

ACKNOWLEDGEMENTS

Our thanks go to the PARTAGE project of IUCN Mauritania, the Intergovernmental Oceanographic Commission of UNESCO (IOC / UNESCO) and the U3E program of French Cooperation for their financial support. We thank Dr Daniel Pauly (University of British Columbia) for the training offered on ELEFAN software.

REFERENCES

- [1]. Albaret J.J., 1992. Mugilidae. In: Faune des poissons d'eaux douces et saumâtres d'Afrique de l'Ouest Tome 2. Levêque C., Paugy D., Teugels G. G. (eds.), pp. 28: 780-788. Coll. Faune Trop. Musée Royal de l'Afrique Centrale, Tervuren, Belgique and ORSTOM, Paris, France.
- [2]. Albaret J.J., 2003. Mugilidae. In: The Fresh and Brackish Water Fishes of West Africa. Paugy D., Lévêque C., Teugels G. G., (eds.), pp. 601-611, IRD Editions, Paris.
- [3]. Bernardon M., Vall M.O.M., 2004. Le mullet en Mauritanie: biologie, écologie, pêche et aménagement. Fondation Internationale du Banc d'Arguin-Programme Régionale Conservation de la zone côtière et Marine en Afrique de l'Ouest-Union Internationale pour la Conservation de la Nature, Nouakchott, 54pp.
- [4]. Brusle J., 1981. Sexuality and biology of reproduction in grey Mullet. In: Aquaculture of grey mullet. Oren International Biological Programme (ed.), 26: 99-154.
- [5]. Farrugio H., 1976. Les muges (Poissons Téléostéens) de Tunisie. Répartition et Pêches. Contribution à leur étude systématique et biologique. U.S.T.L. Montpellier, France. 201 p. Thesis.
- [6]. Harrison I.J., 2003. Mugilidae. In: The Freshwater Fishes of Europe. Miller, P. J., (ed.), pp. 8: 1-42. Wiebelsheim: AULA-Verlag.
- [7]. Ibañez-Aguirre A.L., Gallardo-Cabello M., Carrara X.C., 1999. Growth analysis of striped mullet, *Mugil cephalus*, and white mullet, *M. curema* (Pisces: Mugilidae), in the Gulf of Mexico. Fish. Bull. 97:861-872.
- [8]. Kesteven G., 1942. Studies in the biology of Australian mullet. 1. Account of the fishery and preliminary statement of the biology of *Mugil dobula* Günther. Aust. Counc. Sci. Industr. Res. Bull. 157:1-147.
- [9]. Ndour I., Diadiou H.D., Thiaw O.T., 2013. Reproduction of yellow mullet *Mugil cephalus* on Northern Coast of Senegal, West Africa. AACL Bioflux 6(5):439-445.
- [10]. Ndour I., Diadiou H.D., Thiaw O.T., 2014. Some reproductive aspects of black mullet *Mugil capurrii* on the Northern coast of Senegal, West Africa. AACL Bioflux 7(5):405-411.
- [11]. Pauly D., David N., 1981. ELEFAN I, a basic program for the objective extraction of parameters from length-frequency data. Meeresforsch. 28, 205-211.
- [12]. Sarr S.M., Kabré A.J.T., Niass F., 2013. Régime alimentaire du mullet jaune (*Mugil cephalus*, Linnaeus, 1758, Mugilidae) dans l'estuaire du Fleuve Sénégal. Journal of Applied Biosciences, 71: 5663-5672.
- [13]. Thomson J.M., 1966. The grey mullets. Oceanography and Marine Biology: An annual review 4: 301-335.
- [14]. Thomson J.M., 1997. The Mugilidae of the world. Mem Qld Mus 41(3): 457-562.
- [15]. Trape S., Blel H., Panfili J., Durand J.D., 2009. Identification of tropical Eastern Atlantic Mugilidae species by PCR-RFLP analysis of mitochondrial 16S rRNA gene fragments. Biochemical Systematics and Ecology 37: 512-518.
- [16]. Tung I.-H., 1970. Studies on the fishery biology of the grey mullet, *Mugil cephalus*, in Taiwan. p. 491-504. In J.C. Marr (ed.) The Kuroshio: a symposium on Japan current. East West Center Press, Honolulu.
- [17]. Vincent M., 2010. Growth rate of *Mugil cephalus* from two isolated Ponds in Huntington Beach State Park, South Carolina. 27p.
- [18]. Whitfield A.K., Panfili J., Durand J.D., 2012. A global review of the cosmopolitan flathead mullet *Mugil cephalus* Linnaeus 1758 (Teleostei: Mugilidae), with emphasis on the biology, genetics, ecology and fisheries aspects of this apparent species complex. Rev Fish Biol Fisheries, 22:641-681.

Author' biography

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