Journal Academica Vol. 4(4), pp. 121-129, December 31 2014 - Environmental Science - ISSN 2161-3338
online edition www.journalacademica.org © 2014 Journal Academica Foundation

Full Length Research Paper

Reproductive Biology and Growth of Red Mullet, *Mullus Surmuletus* (Linne, 1758) in Western Algeria Coasts

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Received August 30, 2014; Accepted December 9 2014

ABSTRACT

The biology of red mullet *Mullus surmuletus* was studied from collections taken of the Mostaganem coast (Western Mediterranean) between January and December 2009. Total length ranged from 12 to 25 cm. Females dominated the larger size-classes (> 20 cm). Length frequency distribution according to sex revealed that the females were highly representative in the majority of size classes. The reproductive period activity of the females centers around spring. The total length at 50% maturity for females was 17.5 cm. The length-mass relationship for all individuals can be described by the parameters a =0.009 and b = 2.934. Fish aged 0-8 years were present in the samples. The parameters of the Von Bertalanffy growth equation obtained for females were L_∞= 24.70 cm, k = 0.37 cm / year, and t_0 = - 0.37 year. For males L_∞= 25.52 cm, k = 0.32 cm / year, t_0 = - 0.71 year. Significant differences were found in the growth parameters between males and females.

Keywords: Mullus surmuletus, Mostaganem, reproductive period, relationship, growth

1. INTRODUCTION

Red mullet *Mullus surmuletus* [1] is a demersal marine fish that inhabits sandy and rocky substrata, usually at depths <200 m [2]. It is distributed along the European and African coasts of the Atlantic Ocean, from the English Channel to Dakar, and around the Canary Islands. It is also widely distributed in the Mediterranean and Black seas [3, 4].

Mullus surmuletus biology has not been extensively studied, and but few papers deal exclusively with this species. [5] studied its spawning and larval development in captivity, while [6] N'Da (1992) and [7] studied its diet and sexual cycle on the Brittany coast, France.

In the Mediterranean, most investigators have studied *Mullus surmuletus* jointly with *M. barbatus,* and reports are available comparing chemical composition [8], age and growth [9,10,11,12], reproduction [13], trophic relationships [14,15], and biological and fishing aspects [16,17] of both species.

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Only [18] and [19] have studied some biological aspects of this specie in Algeria.
The present study is an extension of her work, reproductive and analysing the age, growth aspects of *M. surmutetus* in Mostaganem (Northwest Algeria).

2. MATERIALS AND METHODS

A- Reproduction study

Length frequency data (*n* =838) were obtained from red mullet collected fortnightly between January and December 2009 from small-scale fleets working from Mostaganem coast (Fig. 1). A subsample was taken from each sample for biological examination (*n* = 838). Total length (*TL*) was measured to the nearest millimetre and total body mass (*WT*) was recorded to the nearest 0.01 g. Sex and stage of maturity were then determined macroscopically and gonad mass (*GM*) was taken to the nearest 0.01 g. The stages of maturation were classified as follows: I, immature; II, resting; III, ripe; IV, ripe and running; V, spent.
The sex ratio was analysed by size-class. The spawning season was determined by following the monthly evolution of the gonadosomatic index (*GSI*), according to [20]: *GSI* = 100 GM / *WT*.
To monitor morphological variations, the condition index was calculated to assess the degree of overweight consecutive to genital development and repletion state of the target species. Condition factor was studied in females in order to show differences of Kn [21] related to time, according to the formula: $Kn = W_T/W_{th}$ with $W_{th} = a\ L_T^b$ where "W_T" is the total weight, "W_{th}" is the theoretical weight, "a" and "b" are coefficients of the relative growth between weight and length and "L_T" is total length.
For estimation of the length at sexual maturity (length at 50% maturity), a logistic function was fitted to the proportion of mature individuals (Stages III, IV and V) by size-class, using a non-linear regression [22], $P = 1 / \{1 + \exp[-b*(L-Lm_{50})]\}$.
Where, (*P*) is the proportion of mature individuals at length (*LT*), a and *b* is a parameter determining the slope of the maturity curve and *Lm50* is the total length at which 50% of the fish are mature. The relationship between *TL* and *WT* was established by linear regression [23], both for males and females separately and for the whole population.

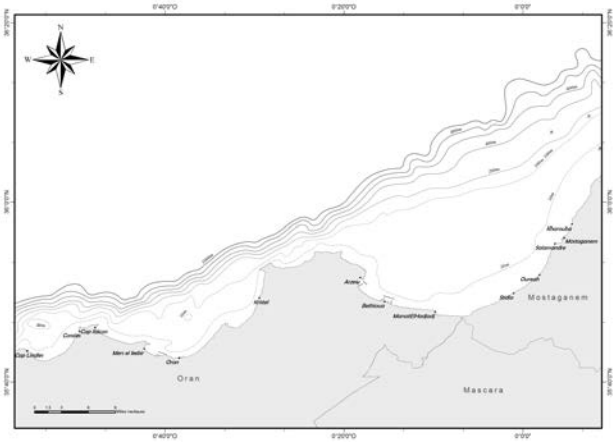

Figure 1: Study area (Northwest Algeria)

B- Growth study

The values of growth parameters were calculated using the software FISAT II (subroutine ELEFAN) [24]. Tables 3 report values of L_∞ (asymptotic length), k (coefficient of growth), t_o (the theoretical age at which the size is zero), also for Ø (growth index). These values, once estimated for *M. surmuletus* specimens, were then replaced in the equation of Von Bertalanffy. Parameters obtained from the equation of Von Bertalanffy did not differ significantly between the two sexes; but asymptotic length, growth rate and growth index resulted slightly different in males. Length frequency data were converted to age frequencies using the estimated Von Bertalanffy growth parameters [25, 26].
Biometric relations observed by analysis of relative growth are shown in Table 2.

This relationship indicates an upper bound of allometry (b greater than 3) for females in all months of the year. We can say that the weight of the species grows faster than the cube of length. Such an allometric relationship was observed also in males. In fact, the lower bound also appeared in the allometry of males. The fitting of a and b ($W_{th}= aL^b$) was employed as input data in stock assessment models.

3. RESULTS AND DISCUISSION

A- Reproduction

1. Size distribution

The total length of red mullet collected during the sampling period ranged between 12 and 24 cm. With reference to the distribution of males and females in the *Mullus surmuletus* samples, the females predominate in all months (Fig. 2). The overall sex-ratio value estimated as 61.57% in favour to females. Further, females were dominant in all size classes (Fig. 3). Results were compared with theoretical (1.96) at a rate of 95% confidence (Table 1). The calculated value of = 1.62 is less than the value (1.96) given by the table of the z-score; this finding indicates that females are, on average, significantly larger than males.

Table 1: Percentage of sexes in *Mullus surmuletus* (*p<0,05)

Sexe	Total	Percentage
Females	516	*61.57 ± 3.29
Males	322	38.42 ± 3.29
Total	838	100

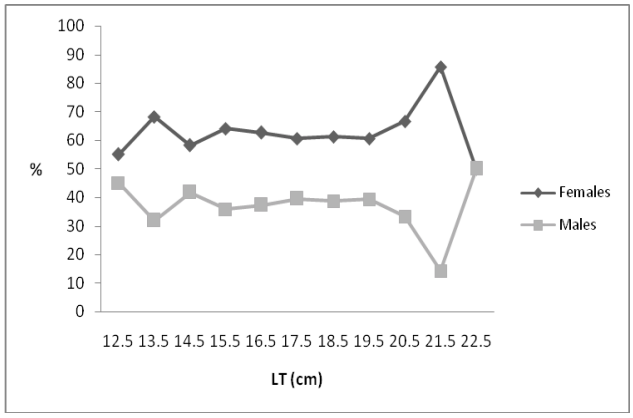

Figure 2: Mean monthly length frequency distribution of *M. Surmuletus*

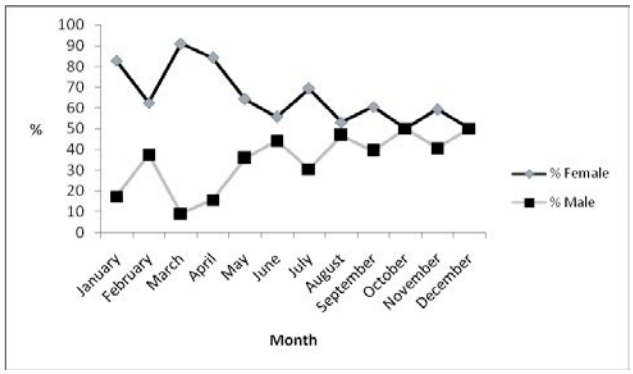

Figure 3: Monthly sex ratios by length-class of *M. Surmuletus*

2. Sexual cycle and spawning period

The gonado-somatic index (GSI) was used to determine the reproductive period, which was calculated from samples taken monthly from males and females. The maximum GSI value was 2.98 in females in May. In June, the GSI value decreased because all samples had presumably dispensed of their eggs (Fig. 4):

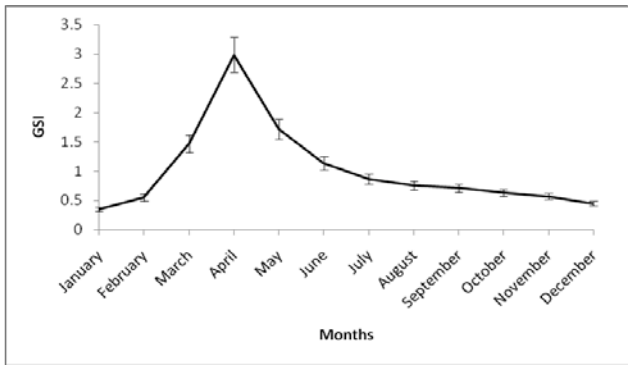

Figure 4: Monthly changes in the gonadosomatic index (GSI) with standard errors of *Mullus surmuletus*

After July, the gonads began to develop and the values of GSI again started to gradually increase until February. Our findings suggest that the reproductive period of this species occurs regularly between March and June.

As regards the sexual maturation of females, different stages of maturation of the gonads during different months of the year are shown in Figure 5:

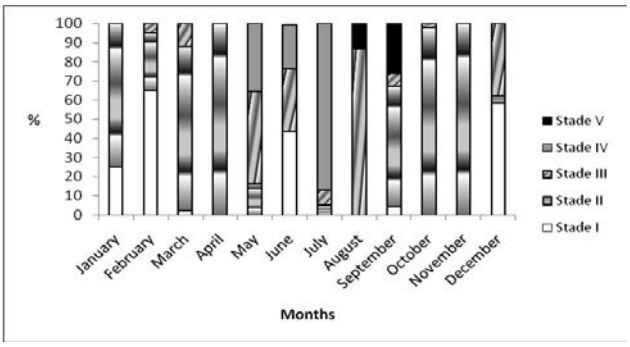

Figure 5: Percentages of different stages of sexual maturity in *Mullus surmuletus* females per month

Figure 6 shows the condition factor Kn by seasons in females sex. The values of Kn resulted overweight, thus revealing breeding events and confirming a rapid maturation occurring from March to May.

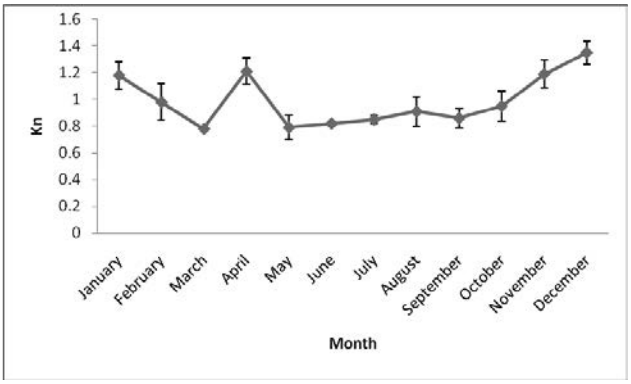

Figure 6: Condition index (Kn) with standard error according to the season in *Mullus surmuletus* females

3. Size at First Sexual Maturity

The smallest mature female observed during the present study was 12.3 cm *TL*, whereas the smallest mature male was 12 cm *TL*. The estimated mean size at which 50% of females were mature was 17.70 cm (Fig. 7):

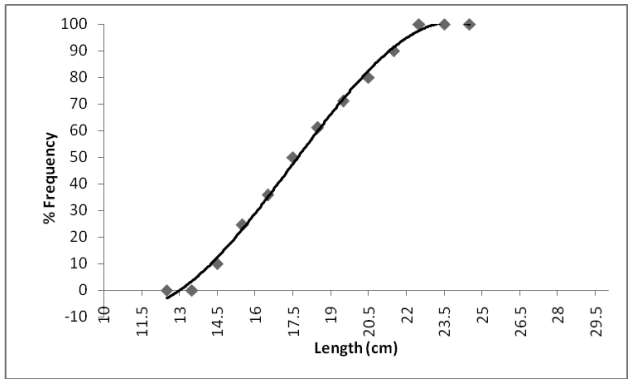

Figure 7: Size at first sexual maturity of *Mullus surmuletus* (females)

B- Growth

1. Length-Weight Relationship

Of 838 specimens captured, 516 were female and 322 were male. Females measured 12 to 24 cm *TL* (X=*18.21* cm *TL*), males 12.5 to 23.5 cm *TL* (X =*17.69* cm *TL*). The length-weight relationship of *Mullus surmuletus* indicated a positive allometry for female and a negative allometry for male by the following equation:

($W_T = a\ L_T^{\ b}$). The analysis by sex showed a significant difference in the *b* coefficient (Table 2):

Table 2: Biometric Relations *M.surmuletus* (Linne, 1758)

$W_T = a\ L_T^{\ b}$	
Females	$W_\infty = 0{,}009 L_\infty^{3{,}02}$
Males	$W_\infty = 0{,}010 L_\infty^{2{,}98}$

The parameters of the Von Bertalanffy growth equation determined for males and females are shown in Table 3. Significant differences were found between the growth of males and females.

Table 3: Growth parameters for *M.surmuletus* females and males

Sexe	Females				Males			
Parameters	k (cm/yr)	L_∞ (cm)	t_0 (yr)	Ø	k (cm/yr)	L_∞ (cm)	t_0 (yr)	Ø
Results	0,37	24,70	- 0,37	2.35	0,32	25,52	- 0,71	2.32

Table 4: Von Bertalanffy Equation

Sex	Von Bertalanffy Equation
Females	$L_t = 24{,}70(1\text{-}e^{-0{,}37\ (t\ +\ 0{,}37)})$
Male	$L_t = 25{,}52(1\text{-}e^{-0{,}32\ (t\ +\ 0{,}71)})$

Table 5: *Mullus surmuletus*. Length weight and growth parameters in different areas of Mediterranean Sea (F females; M males; F + M females and males; further abbreviations as in Tables 2 and 3)

Sex	L_∞ (cm)	k(cm/year)	t_0 (year)	Ø	a	b	Area	Source
F+M	32.52	0.1097	-3.64	2.06	0.0073	3.10	Catalonia	Sáncez *et al.* (1983)
F	29.75	0.49	-0.31				Sicilian	Andaloro and
M	26.25	0.41	-0.23				Channel	Giarritta (1985)
F	21.82	0.51	-0.112	2.38	0.1403	3.351	Tunisia	Gharbi and
M	19.87	0.49	-0.025	2.28	0.1443	3.28		Ktari (1981a)
F+M	21.51	0.50	-0.116	2.36				
F	31.90	0.20	-2.60	2.32	0.0095	3.1090	Majorca	Renones
M	25.54	0.27	-2.45	2.25	0.0104	3.0672		(1995)
F+M	31.28	0.21	-2.34	2.31	0.0091	3.1203		
F	24.70	0.37	-0.37	2.35	0.009	3.02	Algeria	Kherraz *et al.*
M	25.52	0.32	-0.71	2.32	0.010	2.98		(2014)

4. DISCUSSION

Mullus surmuletus is distributed along the continental shelf and slope down to a depth of > 400 m [27]. In Mostaganem waters, the highest concentration of this species is found between 15 and 60 m depth. Below this depth, the species is replaced by the other mullid species *(M. barbatus)* present in the area. The same features have been observed by [28] for red mullet in Tunisian and Majorcan waters, where they are found at depths between 30 and 90 m and more than 90% of the fish are 0-4 years old.

In the depth strata where the Mostaganem trawling fleet exploits *Mullus surmuletus,* the more frequent lengths in the catches are between 12 and 25 cm. In the age-length relationships these correspond mainly to specimens between 0 and 4 years of age. The results are similar to those

obtained by [10] in Tunisian waters. These authors found that between depths of 30 to 90 m, 90% of the individuals were between 0 and 4 years of age.

The proportionately larger red mullet were caught between February and May. These seasonal differences in the length distribution of the catches may be explained by a concentration of adults due to reproduction in spring, whereas at the end of summer and autumn the recruits resulting from the annual spawning enter the fishery. [10] Also indicated a migration towards shallow waters (from 15 to 60 m in depth) by mature adults in spring and summer, and a concentration of summer and autumn. Recruitment to the bottom takes place in shallow areas, with a displacement towards deeper waters as mullet size increases.

The monthly changes observed in the GSI and the percentage of mature specimens recorded are very similar to results obtained in other areas of the Mediterranean [13,17] and in the Atlantic [7], where this species has also been studied on a microscopic scale. The reproductive activity of females centres around spring.

Red mullet attain sexual maturity during their second year of life, at around 17.70 cm. Similarly; in the Mediterranean they attain sexual maturity between the first and the second years of life [29, 30, 17, 31, and 32].

We observed the presence of gravid females with a maximum of 1.60 RGS in April also, there are resting females in spring and summer; these observations could be explained by the fact that after spawning adult females would regain deep waters. Our results are almost similar to those obtained by other authors. They all define clearly the spawning period in spring; this situation is common to the complete the Mediterranean coast [33] and in the Ionian Sea [34].

The results of the study of the condition index (Kn) in females, set and confirm the spawning period in the range from March to May, the value of Kn begins to decrease with a minimum in May, which could be explained by a loss of organic matter associated with the laying period.

The positive allometry of the length weight relation-ship for the whole population agrees with results of other studies (Table 5). The differences between females and males, with a larger allometric coefficient in females than in males, are probably due to the different length distributions of the two sexes. In the size weight relationship, this difference between females and males as a whole means that the portion of the population > 21 cm in length has a very low proportion of males (Fig. 2).

As a whole, growth of *Mullus surmuletus* is fast, with females growing at a slightly slower rate than males. There is no apparent difference in the maximum age between sexes, but females are predominant in Age Classes IV and V. The growth of *Mullus surmuletus* recorded in our study is very similar to that reported for this species in other areas, except in Catalonia where it is lower (Table 5). However, the calculated growth parameters describe the exploited population for the trawl fishery, where the oldest fish were 7 yr of age.

Finally, our results suggest a life cycle for *Mullus surmuletus* similar to that proposed for *M. barbatus* [10, 13], the other mullid species present in the study area. These two species also display a high dietary overlap [14, 15]. However, two mechanisms enable the coexistence of both species in the same

area. First, spawning and the recruitment of both species are temporally separated. *M. surmuletus* begins reproduction in March, with recruitment to the bottom from August onwards, whereas *M. barbatus* reproduces from April to July and recruits to the bottom in September-October. Moreover, differences in their bathymetrical distribution allow the coexistence of different length ranges of each species, which probably enables the partitioning of food resources.

5. ACKNOWLEDGEMENTS

We thank the Algerian Ministry of Higher Education and Scientific Research (MESRS) which funded this experimental study within the framework of CNEPRU project No F01820090008. We are grateful to anonymous reviewers for the constructive critics of an earlier draft.

6. REFERENCES

[1] Linnaeus C. 1758: Systema naturae per Regna Tria Nature secundum classes ordinus

[2] Hureau, J.C. (1986): Mullidae. In *Fishes of the North-Eastern Atlantic and the Mediterranean.* Whitehead, P.J., Bauchot, M.L., Hureau, J.C., Nielsen, J., E. Tortonese (Eds). Paris; UNESCO: 877-882

[3] Ben Tuvia, A. (1981): Mullidae. In *F.A.* O. *Species Identification Sheets jar Fishery Purposes. Eastern Central Atlantic, Fishing Areas* 34, 47 *(in part).* Fisher, W., Bianchi, G., Scott, W.B. (Eds). Ottawa; F.A.O. (un-paginated)

[4] Ben Tuvia, A. (1990): Mullidae. In *Check-list of the Fishes of the Eastern Tropical Atlantic.* Quero, J. C., Hureau, J. C., Karrer, c., Post, A. and L. Saldanha (Eds). Paris; UNESCO: 827-829

[5] Menu B., Girin, M. (1978): Ponte, incubation et developpement larvaire du rouget de roche *(Mullus surmuletus)* en laboratoire. Vie Milieu 29 (3 AB): 517-530

[6] N'Da, K. (1992): Regime alimentaire du rouget de roche *Mullus surmuletus* (Mullidae) dans Ie nord du golfe de Gascogne. *Cybium* 16:159-167

[7] N'Da, K., Deniel, C. (1993): Sexual cycle and seasonal changes in the ovary of the red mullet, *Mullus surmuletus,* from the southern coast of Brittany. *J. Fish BioI. 43:* 229-244

[8] Fernández, R., Val, M.J. (1966): Contribucion al estudio biologico-quimico del Salmonete de roca *(Mullus surmuletus* L.) y del de fango *(Mullus barbatus* L.), de M/tlaga. Boln Inst esp Oceanogr 124

[9] Bougis, P. (1952): Recherches biometriques sur les Rougets *(Mullus barbatus* et *M. surmuletus* L.). *Archs Zool. Expo.gen.* 89(2): 57 -174.

[10] Gharbi, H., Ktari, M.H. (1981(a)): Biologie de *Mullus barbatus* Linnaeus, 1758 (Poissons, Téléostéens, Mullidés) des côtes tunisiennes : taille et âge de première maturité sexuelle, cycle sexuelle et coefficient de condition. *Bull .Inst . Natn. Scient. Tech. Océanogr. Pêche. Salammbô, 8*:41-51

[11] Andaloro, F., Giarritta, P.S. (1985): Contribution to the knowledge of the age and growth of striped mullet, *Mullus barbatus* (L. 1758), and red mullet, *Mullus surmuletus* (L. 1758), in the Sicilian Channel. *FA.O. Fish. Rep.* 336: 89-92

[12] Morales-Nin, B. (1986): Age and growth of Mullus barbatus and M. surmuletus from the Catalan Sea. Rapp P-V Réun Comm Int Explor Sci Mer Méditerr Monaco 10:232

[13] Gharbi, H., Ktari, M.H. (1981(b)): Croissance des rougets en Tunisie. *Bull. Inst. Natn. Scient. Tech. Océanogr. Pêche. Salammbô, 8*: 5-40

[14] Gharbi, H., Ktari, M.H. (1979): Régime alimentaire des rougets *(MulIus barbatus* Linnaeus, 1758 et *Mullus surmuIetus* Linnaeus, 1758) du golfe de Tunis. Bull Inst Oc6anogr P~che, Salammb6 6 (1-4): 41-52

[15] Golani D., Galil, B. (1991): Trophic relationship of colonizing and indigenous goatfishes (Mullidae) in the eastern Mediterranean with special emphasis on decapod crustaceans. Hydrobiologia 218:27-33

[16] Bruno J., P. Oliver, A. Astudillo, X. Pastor and E. Daroca (1979) Contribution a la connaissance de la biologie du merlu (Merluccius merluccius L.) et du rouget (Mullus surmuletus L. et Mullus barbatus L.). Rapp. Comm. Int. Mer Médit., 25/26(10): 79–86

[17] Sanchez P., Morales-Nin, B., Martin, P. (1983): The mullets *(Mullus surmuletus* L. 1758, *Mullus barbatus* L. 1758) of the Catalan coast: biological and fishing aspects (mimeo). Int Counc Explor Sea Comln Meet (Demersal Fish Comm) G: 27:1 19

[18] Djabali F., Brahmi B., Maamass, M. (1993): Poissons des côtes Algériennes. *Pelagos (NS),* 1-215

[19] Derbal, F., Kara, M.H. (2001): Inventaire des poissons des côtes de l'est algérien. *Rapp. Comm. Int. Mer Médit.,* 36: 258

[20] Anderson, R.O., Gutreuter, S.J. (1983): Length, weight, and associated structural indices. Pages 283-300 in L. A. Nielsen and D. L. Johnson, Eds. Fisheries techniques. American Fisheries Society, Bethesda, MD

[21] Le Cren (Ed.) (1951): The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). Journal of Animal Ecology, 20, 201-219

[22] Saila, S.*B.,* Recksiek, C.W., Prager, M.H. (1988): *Basic Fishery Science Programs. A Compendium of Microcomputer Programs and Manual of Operation.* Amsterdam; Elsevier: 230 pp. *(Developments in, Aquaculture and Fisheries Science* 18)

[23] Ricker, W.E. (1973): Linear regressions in fishery research. *J. Fish. Res. Bd Can.* 30(3): 409-434

[24] Gayanilo, J.R., Sparre, P., Pauly, D. (1994): *The FAO-ICLARM Stock Assessment Tools (FISAT) User's Guide.* FAO Computerized Information Series (Fisheries) Nº 6. Rome, FAO, 186 p.

[25] Pauly, D. (1983): Length-converted catch curves: a powerful tool for fisheries research in the tropics (Part 1). *Fishbyte* 1:9-13.

[26] Pauly, D. (1984): Fish population dynamics in tropical waters: A manual for use with programmable calculators. ICLARM Studies and Reviews 8. ICLARM, Manila, Philippines., 325 pp.

[27] Bauchot, M.L. (1987): Mullidae. In: Fisher W, Bauchot ML, Schneider (Eds.) Fiches F.A.O. d'identification des esp6ces pour les besoins de la pèche 37. Vol. 2. Vert6br6s. FAO, Rome, pp 1195-1200

[28] Gharbi, H. (1980): Contribution à l'étude biologique et dynamique des rougets *(Mullus barbatus Linnaeus, 1758 et Mullus surmuletus Linnaeus, 1758)* des côtes tunisiennes. Thèse doctorat de spécialité (3ème cycle de biologie marine) Université de Tunis, Fac. Sic. Tunis: 100 p.

[29] Hashem, M.T. (1973): Some biological studies on the goat fish (M. surmuletus L.) in the Egyptian Mediterranean waters. Bull. Inst. Oceanogr. Fish., 13 : 78p

[30] Andaloro, F. (1982): Résumé des paramètres biologiques sur *Mullus surmuletus* de la mer Tyrrhenienne méridionale et de la mer Ionienne septentrionale. *F.A.O. Fish. Rep. 266:*87-88

[31] Bertrand, L. (1991): Typologie des ressources halieutiques du golfe du Lion et application au problème du maillage des chaluts de fond. *FA.O. Fish. Rep,* 447: 151-159

[32] Morales-Nin, B. (1991): Parametros biologicos dei salmonete de roca *Mullus surmuletus* (L. 1758), en Mallorca. Boln Inst esp Oceanogr 7:139-147

[33] Gordon, J.D.M., Duncan, J.A.R. (1985b): The biology of fish of the Family Moridae in the deep-water of the Rockall Trough. Journal of the Marine Biological Association of the United Kingdom 65: 475-485

[34] Matarrese, A, D´Onghia, G., Basanisi, M., Mastrototaro, F. (1998): Spawning and recruitment of *Phycis blennoides* (Phycidae) from the North-Western Ionian Sea (middle-eastern Mediterranean). Italian Journal of Zoologie, 65, 203-209. doi: 10.1080/11250009809386814