Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 23(5): 31 – 42 (2019)
www.ejabf.journals.ekb.eg

Population Dynamic Parameters of the Comber *Serranus Cabrilla* (Teleostei, Serranidae) in Western Mediterranean (Eastern Coast of Algeria)

Mounira Rachedi* and Amina Tania Dahel
Department of Marine Sciences, Faculty of Natural Sciences and Life, Chadli Bendjedid University, B.P 73, 36000 El-Tarf, Algeria.
* Correspondence Author: rachedi.mounira@yahoo.fr

ARTICLE INFO

Article History:
Received: July 25, 2019
Accepted: Nov. 28, 2019
Online:Dec. 2019

Keywords:
Serranus cabrilla
Growth parameters
Mortality
Exploitation rate
Mediterranean

ABSTRACT

Some population parameters of the comber, *Serranus cabrilla*, were presented in this study. From January to December 2018, a total of 1250 samples of *Serranus cabrilla* ($11 \leq TL \leq 23.9$ cm, $14.34 \leq TW \leq 157.7$ g), have been studied in the Gulf of Annaba (Eastern coasts of Algeria), based on length-frequency data. FiSAT II software was used for different analyses. The growth parameters of Von Bertalanffy are $L_\infty = 24.94$ cm, k = 0.38 year^{-1} and to = -0.45 year, with a performance of growth (φ') of 2.37. The total (Z) and natural (M) mortality of comber in the Annaba gulf were equal to 1.41 and 0.81 year^{-1} respectively, while the fishing mortality was estimated to 0.60. The exploitation rate is around 0.45 and indicates that the population of comber is lightly under exploited in the study area. The length at first capture (L_{c50}) is equal to 12.04 cm.

INTRODUCTION

The genus *Serranus* belonging the Serranidae family, is represented by 15 species in Mediterranean (Quignard and Tomasini, 2000), including the comber *Serranus cabrilla* (Linnaeus, 1758) which is occurs in the Mediterranean, Western Black Sea and Atlantic (Fisher *et al.*, 1987). It is demersal fish and simultaneous hermaphroditic species inhabiting on rocks, *Posidonia* beds, sandy and muddy bottoms until 500 m of depth and up (Louizy, 2005). According to the fisherman, it is fished in artisanal way in the study area; with gillnets and longline; and moderately commercially exploited as well as in the eastern Mediterranean (Ilhan *et al.*, 2010). On an other hand, it is the most abundant comber among the three congeners found in the gulf of Annaba (*S. cabrilla, S. scriba* and *S. hepathus*)(personal observation).

In spite on its wide distribution, studies on dynamics and exploitation of comber stocks are limited in Atlantic (Garcia-diaz *et al.*, 1997; Gordo *et al.*, 2016), available in Mediterranean for age, growth, mortality and reproduction (Bouain, 1983; Bauchot, 1987; Sabatés, 1990; Tserpes and Tsimenides, 2001; Torçu-Koc *et al.*, 2004; Ilhan *et al.*, 2010; Birim *et al.*, 2016), and rare on the northern coast on Africa. The only available data in this area are from Tunisia and concern reproduction (Bouain, 1981), and linear growth (Bouain, 1983). On the Algerian coasts, only Rachedi *et al.* (2018) studied feeding habits of this species.

Therefore, due to scarcity of the information on the population dynamics and exploitation of *S. cabrilla* in the study area, and which are of prime importance to fishery scientists for the management and rational exploitation of this valuable resource, the present work was interested to investigate growth rates, mortalities (Z, M, F), length at first capture and exploitation rate of this species, using length-frequency data collected in the gulf of Annaba (eastern coast of Algeria) to insure the proper management of this resource.

MATERIAL AND METHODS

From January to December 2018, a total of 1250 individuals of *S. cabrilla* ($11 \leq TL \leq 23.9$ cm; $14 \leq TW \leq 157.7$ g; $13.45 \leq EW \leq 140.2$ g) were collected monthly along the coast of the gulf of Annaba which is situated between Cape of Garde in the west and Cape Rosa in the east (36°54'N, 7°46'E) (Fig. 1). The sample is fished by hand lines and longlines via wholesalers and fishmongers in the city of Annaba. Total length (TL) was measured nearest 0.1 cm, total weighed (TW) and eviscerated weight (EW) were recorded on electronic balance at nearest 0.01 g. Sex was not considered in this study given the simultaneous hermaphroditism of this species (Bouain, 1981; Garcia-Diaz *et al.,* 1997; Ilhan *et al.*, 2010; Birim *et al.*, 2016). The length frequency data collected were grouped into 26 length classes with step of 0.5 cm. For a proper implementation of the FiSAT II analysis, Gayanilo *et al.* (2005) suggested that length classes should be about 20 to 25.

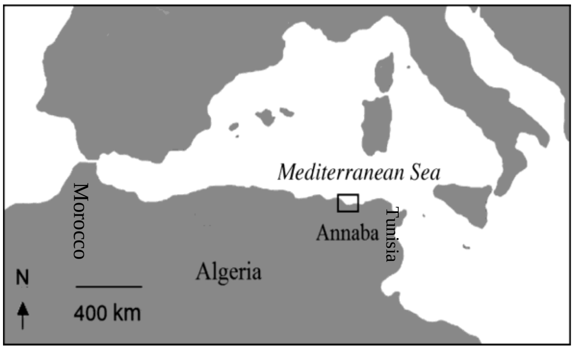

Fig. 1: Location of studied site in the South-Western Mediterranean Sea.

Length-weight relation and condition factor (K)

The relationship between the weight and the length was estimated according to Froese (2006):

$$W = a \times TL^b$$

Where W is the weight (g), TL is the total length (cm), a (intercept) and b (slope). These last two, were estimated by regression curve analyses based on the logarithmic transformed equation (Beverton and Holt, 1957):

$$Log_{10}W = b \times Log_{10} TL + Log_{10} a$$

The Pearson correlation (r) was used as an indicator of significance of regression, and the growth exponent (b) to determine the type of growth (isometric if $b = 3$, allometric if $b \neq 3$) which was tested using t-test (Ricker, 1975). The Fulton Condition factor (K) is used for comparing the condition, fatness, or wellbing (Mir *et al.*, 2012) and was calculated as follow:

$$K = 100 \times EW / TL^3$$

Where EW is the eviscerate weight, TL is the total length.

Growth parameters

The Von Bertallanfy growth parameters ($L\infty$, K and t_0) were estimated in order to describe the growth of fish, where $L\infty$ is the asymptotic length that the individual can reach if it increase indefinitely, K growth coefficient and t_0 age at zero length (TL = 0). The two first parameters were estimated by ELEFANT I (Electronic Length Frequency Analysis) basis on length-frequency data, which were input in FiSAT II 1.2.0 software (Gayanilo *et al.*, 2005).

$$TL = L\infty \times (1 - e^{-k \times (t - t0)})$$

The theoretical age (t_0) was calculated using Pauly's empirical equation (Pauly, 1979) as follow:

$$Log_{10}(-t_0) = -0.3922 – 0.2752 \times Log_{10}(L\infty) - 1.0381 \times Log_{10}(K)$$

The growth parameters of Von Bertallanfy (L∞ and K) were used to compute the performance index (φ′) of the species (Pauly, Munro, 1984) in order to compare the growth of *S. cabrilla* from the study area with those published elsewhere: $\varphi' = \log_{10}(k) + 2 \times \log_{10}(L_\infty)$

Mortality parameters

Using FISAT II software (Gayanilo *et al.*, 2005), the total mortality rate (Z) was estimated from the length-converted catch curve analysis. The natural mortality rate (M) was calculated using Pauly's empirical equation as:

$$\log_{10} M = -0.0066 – 0.279 \times (\log_{10} L\infty) + 0.6543 \times (\log_{10} K) + 0.4634 \times (\log_{10} T)$$

Where L∞ and K are Von Bertalanffy growth parameters, T is the mean annual environmental water temperature of sampling site, which is considered equal to 18 ºC in this study (Ouali *et al.*, 2018). The difference between total and natural mortality rates (Z and M respectively) gave an estimation of fishing mortality rate (F) as F = Z – M, and the exploitation rate as E = F / Z (Pauly, 1984). The stock is optimally exploited when E = 0.5 (F = M), lightly or overexploited (E < 0.5 and E > 0.5 respectively) (Tesfaye and Wolff, 2015). The length at first capture (L_c or L_{c50}) was computed from the length-converted catch curve out put by FiSAT II, it is an important tool for fishery managers, to determine the minimum size of the target species of fishery. The probability of capture (L_c) correspond to the cumulative probability at 50%, while the length at 25 and 75 captures were corresponding to cumulative probability at 25% and 75% respectively.

Relative yield per recruit (Y/R) and biomass per recruit (B/R)

Using Beverton and Holt model (1966); modified by Pauly and Soriano (1986); and introduced to the FAO FiSAT II software, relative yield per recruitment (Y / R) and relative biomass per recruitment (B / R) were estimated using the knife-edge selection procedure as function of the exploitation rate (E) of the species.

RESULTS

According to Figure 2, the length group of 16.5−16.9 cm (11.51%) dominated the sample, followed by those of 17.5−17.9 cm, 17−17.4 cm, 16−16.4 cm, 18−18.4 cm and 18.5−18.9 cm representing respectively 8.95%, 8.79%, 8.45%, 8.47% and 7.35% of the total sampled lengths. We concluded that the medium size are the most fished.

Length-weight relation and condition factor (K)

The length-weight relations were calculated as : $TW = 0.008\ TL^{3.066}$, $EW = 0.009\ TL^{3.01}$ for sex combined (Fig. 3). According to Student's t-test, we observed isometric growth for this species in the study area (r = 0.888 for TL-TW and r = 0.892 between TL-EW; $p \leq 0.001$). The condition factor for *S. cabrilla* was K = 0.848 (± 0.15).

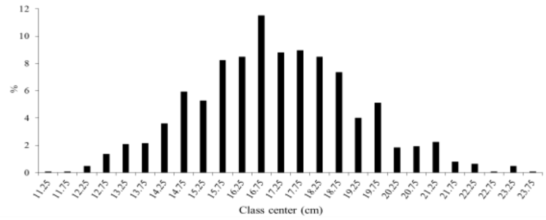

Fig. 2: Size structure of *S. cabrilla* in the gulf of Annaba.

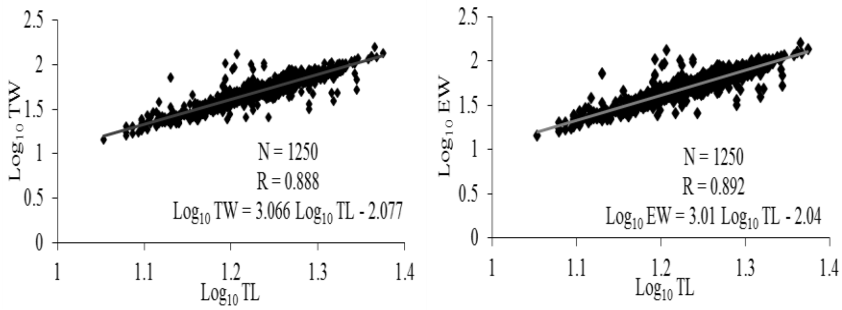

Fig. 3: Length-weight relation-ship of *Serranus cabrilla* in the gulf of Annaba.

Growth parameters

The K-scan technique of FiSAT II and ELEFAN I programme were used to estimated Von Bertalanffy growth parameters: the asymptotic length (L_{∞}) and annual growth coefficient (k) were equal to 2٤.٩4 cm and 0.38 year^{-1} respectively (Fig. 4). The growth performance index (φ') was: 2.37 and the age at zero length (t_o) was estimated to be -0.45 years. The Von Bertalanffy's linear growth equation of *Serranus cabrilla* deriving from the obtained parameters in this study is written as follow: $TL = 24.94\ (1- e^{-0.38(t + 0.45})$

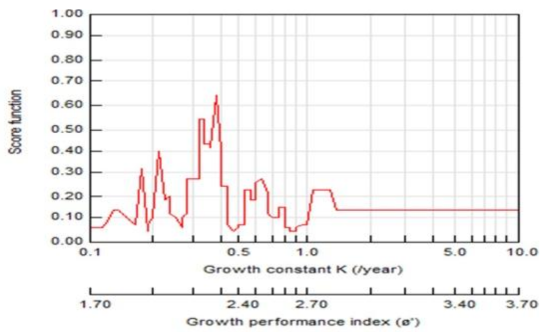

Fig. 4: ELEFAN I K-scan routine FiSAT II software output for *S. cabrilla* from the gulf of Annaba.

Mortality parameters and exploitation ratio

From the 1250 specimens of *S. cabrilla* examined, the instantaneous total mortality (Z), natural mortality rate (M) and fishing mortality (F) were estimated to be Z = 1.41; M = 0.81; F = 0.60 per year, given from the length-converted catch curves (Fig. 5).

The exploitation rate was computed as E = 0.45, it was lower than E_{max} of 0.65, indicating under exploitation of *Serranus cabrilla* in the study area.

The length at first capture (Lc or L_{c50}) was estimated at 12.04 cm, corresponding to an age of 1.95 year (Fig. 6).

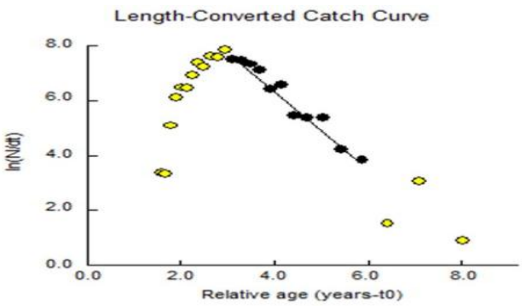

Fig. 5: Length Converted Catch Curve output from FiSAT II software of *S. cabrilla* from the gulf of Annaba.

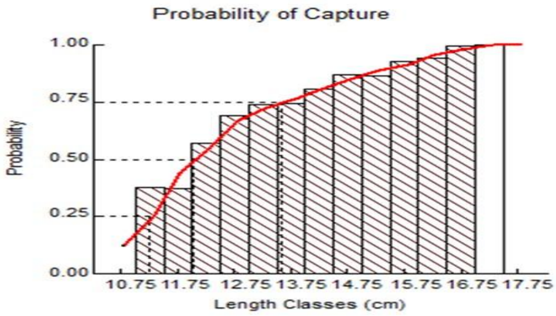

Fig. 6: Length at first capture (Lc) of *S. cabrilla* fished in the gulf of Annaba.

Relative yield per recruit (Y/R) and relative biomass per recruit (B/R)

The relative yield per-recruit analysis using Knife-edge Selection procedure as function of E, showed that the MSY (maximum sustainable yield) would be reached at an exploitation rate equal to 0.65, with E_{10} = 0.567, E_{50} = 0.36 and E_{max} = 0.65. The latter is higher than the current estimated exploitation rate (0.45) (Fig. 7). The value of $Lc/L\infty$, which is equal to 0.481 (Fig. 8) revealed the dominance of juvenile fish in catches landed during the study period.

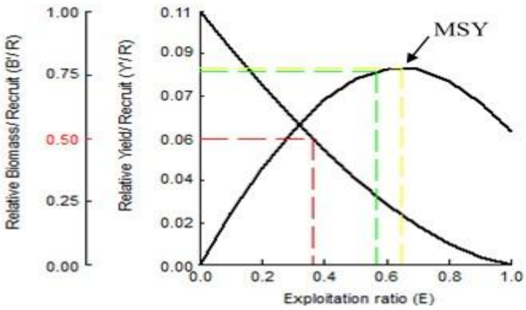

Fig. 7: FiSAT II output for yield-per-recruit and average biomass per recruit plots for *S. cabrilla* from the gulf of Annaba. MSY: Maximum Sustainable Yield.

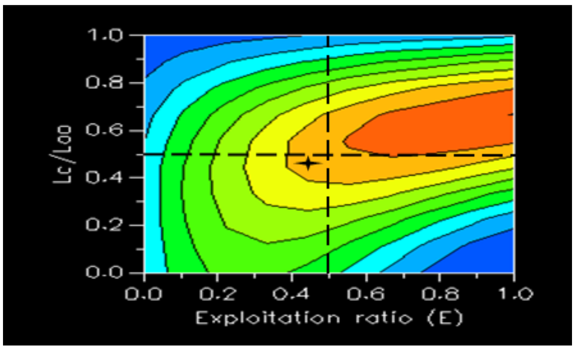

Fig. 8: FiSAT II output for yield-per-recruit analyses isopleth (Knife-edge selection) for *S. cabrilla* of the gulf of Annaba.

DISCUSSION

Dynamics of exploited stocks is a discipline which becoming more and more important in Fisheries Biology, its main purpose is to describe the evolution of stocks of fish, crustaceans or molluscs, exploited by the man (Daget and Le Guen 1975b). To estimate fishery yields and stock biomasses at different fishing strategic levels, the use of mathematical dynamic models were required. According to Dadzie *et al.* (2007), determining growth and mortality of fish populations is important for deriving these models. In this study, we provided results on some population parameters such as length-weight, age and growth, mortality and recruitment pattern of exploited stock of *S. cabrilla* in the gulf of Annaba (eastern coast of Algeria). In this purpose, length frequency data was used to analyse these parameters.

In the study area, the maximum total length of *Serranus cabrilla* recorded is 23.9 cm, it is higher than those reported in different localities of the Mediterranean as Tserpes and Tsimenides (2001)(TL = 19.7 cm), Torçu-Koc *et al.* (2004)(FL = 22.1 cm) and Ilhan *et al.* (2010)(TL = 22.5 cm). On the other hand, it is less than those recorded in the Atlantic by Gonçalves *et al.* (1997) and Gordo *et al.* (2016)(30.2 cm and 26.5 cm, respectively). These differences may be due to selective fishing gear or essentially to differences in biotic and abiotic conditions, overfishing may also be a major reason that certain areas always catch smaller fish.

Length-weight relationship in this study showed that *S. cabrilla* expressed isometric growth with b equal to 3.066, the same results were reported in Atlantic (Gordo *et al.*, 2016), in Mediterranean and specially on Turkish coasts (Moutopoulos and Stergiou 1998; Cicek *et al.*, 2006; Karakulak *et al.*, 2006; Ismen *et al.*, 2007; Çakir *et al.*, 2008; Bök *et al.*, 2011; Cengiz, 2013; Akalin *et al.*, 2015; Oztekin *et al.*, 2016) (Table 1).

Table 1: Length-weight relationship of *S. cabrilla* according to literature and in different areas.

Authors	**Countries**	**Length-weight relationship**
	Isometric growth	
Current study	Gulf of Annaba (Algeria)	$TW = 0.008\ TL^{3.066}$
Gordo *et al.*, 2016	Atlantic (Portuguese coast)	$TW = 0.0097\ TL^{3.05}$
Oztekin *et al.*, 2016	Aegean sea, Turkey	$TW = 0.0164\ TL^{2.90}$
Akalin *et al.*, 2015	Candarli Bay, Turkey	$TW = 0.0091\ TL^{3.09}$
Cengiz, 2013	Gallipoli, Turkey	$TW = 0.0116\ TL^{3.03}$
Bök *et al.*, 2011	Marmara Sea, Turkey	$TW = 0.0091\ TL^{3.18}$
Çakir *et al.*, 2008	Edremit bay, Turkey	$TW = 7.\ 10^{-5}\ TL^{2.62}$
Ismen *et al.*, 2007	Saros bay, Turkey	$TW = 0.0086\ TL^{3.06}$
Cicek *et al.*, 2006	North East Mediterranean	$TW = 0.0131\ TL^{2.89}$
Karakulak *et al.*, 2006	Aegean sea, Turkey	$TW = 0.0112\ TL^{2.99}$
Moutopoulos and Stergiou, 1998	Aegean sea, Turkey	$TW = 0.0107\ TL^{3.001}$
	Negative allometry	
Altin et *et al.*, 2015	Golfe d'Antalya, Turquie	$TW = 0.012\ TL^{2.90}$
Kapiris and Klaoudatos, 2011	Aegean sea, Turkey	$TW = 0.5.\ 10^{-4}\ TL^{2.71}$
Torcu-Koc *et al.*, 2004	Edremit bay, Turkey	$TW = 0.0311\ TL^{2.67}$
Abdallah, 2002	Alexandria, Egypt	$TW = 0.039\ TL^{2.55}$
Moutopoulos and Stergiou, 2002	Aegean sea, Turkey	$TW = 0.0186\ TL^{2.805}$
Torcu *et al.*, 1998	Edremit bay, Turkey	$TW = 0.0353\ TL^{2.61}$
Goncalves *et al.*, 1997	Atlantic (Portuguese coast)	$TW = 0.7.\ 10^{-4}\ TL^{2.66}$
Merella *et al.*, 1997	Balearic Islands (Mediterranean)	$TW = 0.016\ TL^{2.82}$
Petrakis and Stergiou, 1995	Greece	$TW = 0.022\ TL^{2.92}$
Papaconstantinou *et al.*, 1994	Aegean sea, Turkey	$TW = 0.0276\ TL^{2.725}$
	Positive allometry	
Ozvarol, 2014	Antalya gulf, Turkey	$TW = 0.0091\ TL^{3.04}$
Sangan *et al.*, 2007	North East Mediterranean	$TW = 0.0662\ TL^{3.22}$

However many studies recorded negative allometry in Mediterranean (Papaconstantinou *et al.,* 1994; Petrakis, and Stergiou 1995; Merella *et al.,* 1997; Torcu *et al.,* 1998; Abdallah, 2002; Moutopoulos and Stergiou 2002; Torcu-Koc *et al.,* 2004; Kapiris and Klaoudatos 2011; Altin *et al.,* 2015), and in Atlantic (Goncalves *et al.,* 1997) (Table 1). Only Sangan *et al.* (2007) and Ozvarol (2014) showed that the weight of the individual fish grows faster than its lengths (majored allometric) (Table 1). This dissimilarity of results between the areas might be related to the seasons, maturity stages, feeding behavior, sampling methods or sample size of different studies.

Mir *et al.* (2012) reported that, if the condition factor values are less than one are considered as being low, and while those greater than one are considered as high. In the present study, the condition factor of *S. cabrilla* (K = 0.848) showed that this species doesn't grow well in the study area, probably due to parasitism, especially since we found a lot of parasites (nematodes) in the digestive tracts (Rachedi *et al.,* 2018) and gonads of the individuals (personal observation, unpublished data). Bouain (1981) found higher values oscillating between 1.23 and 2.31 on the south coast of Tunisia. According to Le Cren (1951), environmental factors, food supply and parasitism have great influence on the health of the fish.

The asymptotic length (L_∞) in the present work was calculated from K-scan technique in ELEFAN I. According to the literature (Table 2) the estimated asymptotic length (L_∞= 24.94 cm) is close to what was found in Mediterranean by Papaconstantinou *et al.* (1994) and in Atlantic by Gordo *et al.* (2016) but slightly higher than those reported by Politou and Papaconstantinou (1995), Tserpes (1996), Tserpes and Tsimenides (2001) and Ilhan *et al.* (2010) in the Mediterranean. In contrast, on the Tunisians coast (Bouain 1983) and in the Aegean sea (Torcu-Koc *et al.,* 2004), a high values of the asymptotic length were reported equal to 31.85 cm and 33.55 cm respectively (Table 2).

Table 2: Growth parameters of *S. cabrilla* in different countries (Von Bertalanffy growth parameters: L_∞, K; growth performance index (φ′)).

Authors	Regions	L_∞ (cm)	K (year^{-1})	φ′
This study	Gulf of Annaba (Algeria)	24.94	0.38	2.37
Gordo *et al.,* 2016	Portuguese coasts, Atlantic	25.26	0.21	2.13
Ilhan *et al.,* 2010	Aegean Sea, Turkey	23.88	0.30	2.23
Torçu-Koc *et al.,* 2004	Aegean Sea, Turkey	33.55[a]	0.11	2.43
Tserpes and Tsimenides, 2001	Crete, Greece	22.39	0.38	2.28[c]
Tserpes, 1996	Cretan Sea	23.54	0.34	2.28[c]
Politou and Papaconstantinou, 1995	Northern Greece	23.81	0.30	2.23
Papaconstantinou *et al.,* 1994	Northern Greece	25.8	0.30	2.30[c]
Bouain, 1983	Tunisia	31.85[b]	0.10	2.01[c]

Notes: [a] Fork length, [b] Standard length, [c] calculated from published L_∞ & k data.

This can be explained by the different environmental conditions, biological features, feeding, intra- or interspecific competition (Panfili *et al.,* 2002), also can be the age at maturity, sample size or sampling methods. The Von Bertalanffy curvature parameter of *S. cabrilla* of the gulf of Annaba (K = 0.38 year^{-1}) is comparable to that of Tserpes and Tsimenides (2001) in Greece, close to those of Papaconstantinou *et al.* (1994) and Politou and Papaconstantinou (1995) in northern Greece, Tserpes (1996) in Cretan sea and Ilhan *et al.* (2010) in Aegean Sea (Turkey) (table 2). However, the growth coefficient recorded in this study is higher than that reported by Bouain (1983) on the Tunisian coasts (K = 0.1 year^{-1}) and Gordo *et al.* (2016) in Atlantic (K = 0.21 year^{-1}). It is theoretically admitted that growth parameters L_∞ and K are negatively correlated, when L_∞ is high, the K is low (Murugan *et al.*, 2014). Gulland (1970) and Bartulovic *et al.* (2004) reported that there must be some differences between growth parameters among areas because of the diversity and availability of dietary items, hydrographical and climatic conditions.

The value of the growth performance index (φ′) recorded in this study is equal to 2.37, it is between the minimum 2.01 (Bouain 1983) and maximum 2.43 (Torçu-Koc *et al.*, 2004) recorded in Mediterranean (table 2). The variations in growth performance index could be due to different methods used to age readings, environmental conditions (temperature, geographic location,….).

Mortality estimates associated to growth parameters are important to understand population dynamics (Ralston and Williams 1988). The values of natural and fishing mortality of *S. cabrilla* in the study area (M = 0.81, F = 0.60) indicate that the fishing pressure is less than natural mortality, so we do not fishing enough to reach the optimum (M = F). Different results are reported in Mediterranean by Tserpes and Tsimenides (2001) (M = 0.35, F = 0.93) and Torcu-Koc *et al.* (2004) (M = 0.32, F = 0.17). In Atlantic Ocean and along the western Portuguese coast, Gordo *et al.* (2016) obtained a natural mortality ranged from 0.44 to 0.48 with fishing mortality varied between 0.12 to 0.16. According to Rahman *et al.* (2016), the same species may have different rate of natural and fishing mortality in different locations, depending on the density of debris and prey whose affluence is influenced by fishing activities. Tserpes and Tseminides (2001), conclude that even small changes in the growth parameters used could seriously affect the computed mortality rates. The estimates of exploitation rate (E = 0.45) showed that the comber stock is slightly under exploited in the study area, the fact that the exploitation rate obtained is inferior to E_{opt} = 0.5. Contrary to where it was heavily exploited around Crete (Greece) (Tserpes and Tseminides 2001), with exploitation rate around 0.7 while Torku-cok *et al.* (2004) found in Edremit Bay, Aegean sea (Turkey) that the comber is the subject of light to moderate exploitation (E = 0.35).

The probability of capture of *S. cabrilla* in present work, is equal to 12.04 cm, which is less than the length at first sexual maturity recorded in Mediterranean by: Bouain (1981) on Tunisian coasts (L_{t50} = 16 cm), Bauchot (1987) and Torku-cok *et al.* (2004)(L_{50} = 15 cm of standard and fork length respectively), Ilhan *et al.* (2010) and Birim *et al.* (2016) (L_{t50} = 13.2 cm and L_{t50} = 12.9 cm respectively). It could be concluded that the first capture of the comber *S. cabrilla* in the east Algerian coasts is before reaching its first sexual maturity. In these conditions, individuals could not contribute to a renewal of the stock.

The Relative yield per recruit (Y/R) and relative biomass per recruit (B/R) were determined as function of $Lc/L\infty$ and M/K respectively. These tow latter were equal to 0.481 for the first and 2.026 for the second. According to Beverton and Holt (1957), the M/K will always be in the range of 1-2.5, which agree with our result. The $Lc/L\infty$ value indicating a high presence of small-sized fish in the landed catch during the study period, since it is less than 0.5. The presence of juvenile in the catches could be explained by the unselective use of small mesh sized fishing gear.

The population dynamic parameters of the comber *S. cabrilla* on southern Mediterranean coasts, give us more information on its growth and exploitation, which are needed for better management of natural stocks of *Serranus* in southern Mediterranean and especially on Algerian coasts.

REFERENCES

Abdallah, M. (2002). Length-weight relationships of fishes caught by bottom trawl fishing from Egyptian Mediterranean waters, off Alexandria. Naga, The ICLARM Quarterly, 25: 19-20.

Akalin, S.; Ilhan D. and Özaydin, O. (2015). Length-weight relatıonshıps for 30 demersal fısh species from Çandarli Bay (North Aegean Sea, Turkey). Croatian Journal of Fisheries, 73: 73-76. DOI: 10.14798/73.2.822

Altin, A.; Ayyildiz, H.; Kale, S. and Alver, C. (2015). Length-weight relationships of forty-nine fish species from shallow waters of Gökçeada Island, northern Aegean Sea. Turkish Journal of Zoology, 39: 971-975.

Bartulovic, V.; Glamuzina, B.; Conides, A.; Dulcic, J.; Lucic, D.; Njire, J. and Kozul, V. (2004). Age, growth, mortality and sex ratio of sand smelt, *Atherina boyeri*, Risso, 1810 (Pisces: Atherinidae) in the estuary of the Mala Neretva River (Middle-Eastern Adriatic, Croatia). Journal of Applied Ichthyology, 20: 427-430.

Bauchot, M. L. (1987). Poissons osseux. *In*: Fiches FAO d'Identification pour les Besoins de la Pêche (Rev. 1). Méditerranée et mer Noire. Zone de pêche 37. Vol.2. Fischer W.; Bauchot, M. L.; Schneider M. (Eds). CCE & FAO, Rome. 891-1421 pp.

Beverton, R. J. H. and Holt, S. J. (1957). On the dynamics of exploited fish populations. Fisheries Investigations, 19: 1-533.

Beverton, R. J. H. and Holt, S. J. (1966). Manual of methods for fish stock assessment. Part II. Tables of yield function. FAO Fisheries Technical Paper, 38 (ver. 1), 67 pp.

Birim, B. D.; Cihangir, B. and Tirasin, E. M. (2016). The Reproduction Properties of *Serranus cabrilla* (L., 1758) and *Serranus hepatus* (L., 1758) from Izmir. Natural and Engineering Sciences, 1(3): 25.

Bök, D. T.; Göktürk, D.; Kahraman, A.; Aliçli, T.; Acun, T. and Ateş, C. (2011). Length-weight relationships of 34 fish species from the Sea of Marmara, Turkey. Journal of Animal and Veterinary Advances, 10: 3037-3042.

Bouain, A. (1981). Les serrans (Teleostei, Serranidae) des côtes sud de la Tunisie : taille de première maturité, période de reproduction. Cybium, 5: 65-75.

Bouain, A. (1983). La croissance linéaire des serrans des côtes sud-est de la Tunisie. Rapp. P.IV. Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée, 28(5): 87-91.

Çakır, D. T.; Koç, H. T.; Başusta, A. and Başusta, N. (2008). Length-weight relationships of 24 fish species from Edremit Bay, Aegean Sea. E-journal of New World Sciences Academy, 3(1): 47-51.

Cengiz, O. (2013). Length-weight relationships of 22 fish species from the Gallipoli peninsula and Dardanelles (northeastern Mediterranean, Turkey). Turkish Journal of Zoology, 37: 419-422. DOI: 10.3906/zoo-1209-30.

Cicek, E.; Avsar, D.; Yeldan, H. and Ozutok, M. (2006). Length-weight relationships for 31 teleost fishes caught by bottom trawl net in Babadilimani Bight (Northeastern Mediterranean). Journal of Applied Ichthyology, 22: 290-292. DOI: 10.1111/j.1439-0426.2006.00755.x.

Dadzie, S.; Abou-Seedo, F. S. and Moreau, J. (2007). Population dynamics of *Parastromateus nigerin* Kuwaiti waters as assessed using length– frequency analysis. Journal of Applied Ichthyology, 23: 592-597. DOI: 10.1111/j.1439-0426.2007.00903.x.

Daget, J. and LE Guen, J. C. (1975b). Dynamique des populations exploitées de poissons. In Problème d'écologie : La dynamique des populations de vertébrés. Lamotte M. and Bourlière F. (eds): Masson et Cie, Paris, 395-443 pp.

Fischer, W.; Schneider, M. and Bauchot, M. L. (1987). Fiches FAO d'identification des espèces pour les besoins de la pêche. Méditerranée et Mer Noire. Zone de pêche 37, Révision 1, Volume 2, 762-1529 pp.

Froese, R. (2006). Cube law, condition factor, and weight-length relationships: History, meta-analysis, and recommendations. Journal of Applied Ichthyology, 22: 241-253. DOI: 10.1111/j.1439-0426.2006.00805.x.

García-Díaz, M. M.; Tuset, V. M.; González, J. A. and Socorro, J. (1997). Sex and reproductive aspects in *Serranus cabrilla* (Osteichthyes: Serranidae): macroscopic and histological approaches. Marine Biology, 127(3): 379-386. DOI:10.1007/s002270050024.

Gayanilo, F. C.; Sparre, P. and Pauly, D. (2005). FAO-ICLARM Stock Assessment Tools II (FiSAT II). User's guide. FAO Computerized Information Series (Fisheries). No. 8, Revised version. FAO, Rome, 168 pp.

Gonçalves, J. M. S.; Bentes, L.; Lino, P.G.; Riberio, J.; Canario, A. V. M. and Erzini, K. (1997). Weight-length relationships for selected five fish species of the small-scale demersal fisheries of the South-West coast of Portugal. Fisheries Research, 30: 253-256. DOI: 10.1016/S0165-7836(96)00569-3.

Gordo, S. L.; Neves, A.; Vieira, A. R.; Paiva, R. B. and Sequeira, V. (2016). Age, growth and mortality of the comber *Serranus cabrilla* (Linnaeus, 1758) in the eastern Atlantic. Marine Biology Research, 12(6): 656-662. DOI: 10.1080/17451000.2016.1169295.

Gulland, J. A. (1970). The fish resources of the ocean. FAO Fisheries Technical Paper No. 97, FAO, Rome, 425 pp.

Ilhan, D.; Akalin, S.; Tosunoglu, Z. and Özaydin, O. (2010). Growth caracteristics and reproduction of comber, *Serranus cabrilla* (Actinopterygii, Perciformes, Serranidae), in the Aegean Sea (Turkey). Acta Ichthyologica et Piscatoria, 40(1): 55-60. DOI: 10.3750/AIP2010.40.1.07.

Işmen, A.; Özen, O.; Altınağaç, U.; Özekinci, U. and Ayaz, A. (2007). Weight-length relationships of 63 fish species in Saros Bay, Turkey. Journal of Applied Ichthyology, 23: 707-708. DOI: 10.1111/j.1439-0426.2007.00872.x.

Kapiris, K. and Klaoudatos, D. (2011). Length-weight relationships for 21 fish species caught in the Argolikos Gulf (central Aegean Sea, eastern Mediterranean), Turkish Journal of Zoololgy, 35(5): 717-723. DOI: 10.3906/zoo-1003-122.

Karakulak, F. S.; Erk, H. and Bilgin, B. (2006). Length-weight relationships for 47 coastal fish species from the northern Aegean Sea, Turkey. Journal of Applied Ichthyology, 22: 274-278. DOI: 10.1111/j.1439-0426.2006.00736.x.

Le Cren, E. D. (1951). The length-weight relationships and seasonal cycle in gonad weight and condition in perch (*Perca fluviatilis*). Journal of Animal Ecology, 20: 201-219. DOI: 10.2307/1540.

Linnaeus, C. (1758). Systema Naturae per Regna Tria Naturae secundum Classes, Ordinus, Genera, Species cum Characteribus, Differentiis Synonymis, Locis. 10ème ed., Vol. 1. Holmiae Salvii. 824 pp.

Louizy, P. (2005). Guide d'identification des poissons marins. Europe de l'ouest et Méditerranée. (2ème eds) Eugen Ulmer. Paris. 430 pp.
Merella, P.; Quetglas, A.; Alemony, F. and Corbonell, A. (1997). Length-weight relationship of fishes and cephalopods from the Balearic Islands (western Mediterranean). Naga ICLARM Quarterly, 20: 66-68.
Mir, J. I.; Shabir, R. and Mir, F. A. (2012). Length-weight relationship and condition factor of *Schizopyge curvifrons* (Heckel, 1838) from River Jhelum, Kashmir, India. World Journal of Fish and Marine Sciences, 4: 325-329. DOI: 10.5829/idosi.wjfms.2012.04.03.63155.
Moutopoulos, D. K. and Stergiou, K. I. (1998). Length-weight and length relationships for seven fish species of the Aegean Sea. Proceedings of the 20th meeting of the Hellenic Society of Biological Sciences, 20: 207-208.
Moutopoulos, D. K. and Stergiou, K. I. (2002). Weight-length and length-length relationships for 40 fish species of the Aegean Sea (Hellas). Journal of Applied Ichthyology, 18: 200-203. DOI: 10.1046/j.1439-0426.2002.00281.x.
Murugan, S.; Rahman, M. A. U.; Lyla, P. S. and Khan, S. A. (2014). Growth and Population dynamics of flathead grey mullet, *Mugil cephalus* (Linnaeus, 1758) from Parangipettai waters (Southeast coast of India). Thalassas, 30(2): 47-56.
Ouali, N.; Belabed, B. E. and Chenchouni, H. (2018). Modelling environment contamination with heavy metal in flathead grey mullet *Mugil cephalus* and upper sediments from north African coasts of the Mediterranean Sea. Elsevier, Science of the Total Environment, 639: 156-174. DOI: 10.1016/j.scitotenv.2018.04.377.
Oztekin, A.; Özekinci, U. and Daban, I. B. (2016). Length-weight relationships of 26 fish species caught by longline from the Gallipoli peninsula, Turkey (northern Aegean Sea). Cahiers de Biologie Marine, 57: 335-342.
Ozvarol, Y. (2014). Length-weight relationships of 14 fish species from the Gulf of Antalya (north-eastern Mediterranean Sea, Turkey). Turkish Journal of Zoology, 38: 342-346. DOI: 10.3906/zoo-1308-44.
Panfili, J.; Pontual, H. (de).; Troadec, H. and Wright, P. J. (eds.) (2002). Manuel de sclérochronologie des poissons. Co-édition IFREMER-IRD, 464 pp.
Papaconstantinou, C.; Politou, C. Y.; Caragitsou, E.; Stergiou, K. I.; Mytilineou, E.; Vassilopoulou, V.; Fourtouni, A.; Karkani, M.; Kavadas, S.; Petrakis, G.; Siapatis, A.; Chatzinikolaou, P. and Giagnisi, M. (1994). Investigations on the abundance and distribution of demersal stocks of primary importance in the Thermaikos Gulf and the Thracian Sea (Hellas). National Centre for Marine Research, Athens, Hellas, Technical Report, North Aegean Sea Series 4/1994.
Pauly, D. (1979). Theory and management of tropical multi-species stocks. A review with emphasis on the South-east Asian demersal fisheries. ICLARM Studies and Reviews, 35 pp.
Pauly, D. (1984). Fish population dynamics in tropical waters: a manual for use with programmable calculators. International center for living aquatic resources management, ICLARM Studies and Review, 8: 1-325. DOI: 10.1086/414824.
Pauly, D. and Munro, J. L. (1984). Once more on the comparison of growth in fish and invertebrates. Fishbyte, 2(1): 21.
Pauly, D. and Soriano, M. L. (1986). Some practical extensions to Beverton and Holt's relative yield-per-recruit model. In: Maclean, J. L.; Dizon, L. B.; Hosillos, L. V. (eds), First Asian Fisheries Forum, Asian Fisheries Society. Manila, Philippines, 149-495 pp.
Petrakis, G. and Stergiou, K. I. (1995). Weight-length relationships for 33 fish species

in Greek waters. Fisheries Research, 21: 465-469. DOI: 10.1016/0165-7836(94)00294-7.

Politou, C. Y. and Papaconstantinou, C. (1995). Age and growth of comber *Serranus cabrilla* (L. 1785) in the Thracian Sea and the Thennaikos Gulf (Northern Greece). Rapport de la Commission International Mer Méditerranée, 1-34 pp.

Quignard, J. P. and Tomasini, J. A. (2000). Biodiversity Mediterranean Fish Biodiversity. Biologia Marina Mediterranea, 7(3): 1-66.

Rachedi, M.; Derbal, F. and Kara, M. H. (2018). Feeding habits of the comber *Serranus cabrilla* (Linnaeus, 1758) (Teleostei, Serranidae) from the gulf of Annaba (Eastern coast of Algeria), Cahiers de Biologie Marine, 59: 149-158. DOI: 10.21411/CBM.A.7B25A05C.

Rahman, M. A. U.; Chander, P. M.; Lyla, P. S. and Khan, S. A. (2016). Growth and Stock Estimation of Greenback Mullet, *Liza subviridis* (Valenciennes, 1836) from Parangipettai Waters (Southeast Coast of India). Thalassas, 32: 43-50. DOI: 10.1007/s41208-0150005-3.

Ricker, W. E. (1973). Linear regression in fishery research. Journal of the Fisheries Research Board of Canada, 30(3): 409-434. DOI: 10.1139/f73-072.

Sabatés, W. E. (1990). Distribution pattern of larval fish population in the North-western Mediterranean. Marine Ecology Progress Series, 59(1, 2): 75-82. DOI: 10.3354/meps059075.

Sangun, L.; Akamca, E. and Akar, M. (2007). Weight-Length Relationships for 39 Fish Species from the North-Eastern Mediterranean Coast of Turkey. Turkish Journal of Fisheries and Aquatic Sciences, 7: 37-40.

Tesfaye, G. and Wolff, M. (2015). Stock assessment of fishery target species in Lake Koka, Ethiopia. Revista de Biología Tropical (International Journal of Tropical Biology, ISSN0034-7744), 63(3): 755-770.

Torçu, I. I.; Türker, D. and Mater, S. (1998). A preliminary study on some biological aspects of the population of comber (*Serranus cabrilla* Linnaeus, 1785) in Edremit Bay, Northern Aegean Sea. *In*: The eastern Anatolian Region, 3rd Water Production Symposium, 611-616.

Torcu-Koc, H.; Turker-Çakir, D. and Dulcic, J. (2004). Age, growth and mortality of the comber, *Serranus cabrilla* (Serranidae) in the Edremit Bay (NW Aegean Sea, Turkey). Cybium, 28(1): 19-25.

Tserpes, G. (1996). Contribution to the study of the dynamics and fisheries exploitation of the demersal fisheries resources of Cretan waters. Ph. D. Thesis, University of Crete, Greece (in Greek, English abstract).

Tserpes, G. and Tsimenides, N. (2001). Age, growth and mortality of *Serranus cabrilla* (Linnaeus, 1758) on the Cretan shelf. Fisheries Research, 51: 27-34. DOI: 10.1016/s0165-7836(00)00237-X.