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 ≤ TL ≤ 23.9 cm, 14.34 ≤ TW ≤ 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 $t_0 = -0.45$ year, with a performance of growth ($\psi'$) 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.
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 ≤ TL ≤ 23.9 cm; 14 ≤ TW ≤ 157.7 g; 13.45 ≤ EW ≤ 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; García-Díaz *et al.*, 1997; İlhan *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.](image)

**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 \( b ≠ 3 \)) 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:

\[ K = 100 \times \frac{EW}{TL^3} \]

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).

\[
TL = L_\infty \times (1 - e^{-k \times (t - t_0)})
\]

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 (\( L_\infty \) and \( K \)) were used to compute the performance index \( (\varphi') \) 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 \( L_\infty \) and \( K \) are Von Bertalanffy growth parameters, \( T \) is the mean annual environmental water temperature of sampling site, which is considered equal to 18 °C 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 output 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 \((r = 0.888 \text{ for } TL-TW \text{ and } r = 0.892 \text{ between } TL-EW; p \leq 0.001)\). The condition factor for \( S. cabrilla \) was \( K = 0.848 \pm 0.15 \).
Growth parameters

The K-scan technique of FiSAT II and ELEFAN I programme were used to estimated Von Bertalanffy growth parameters: the asymptotic length \( L_\infty \) and annual growth coefficient \( k \) were equal to 24.94 cm and 0.38 year\(^{-1} \) respectively (Fig. 4). The growth performance index \( \phi' \) was: 2.37 and the age at zero length \( (t_0) \) 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:  
\[
TL = 24.94 \left(1 - e^{-0.38(t + 0.45)}\right)
\]

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 \( E_{\text{max}} \) of 0.65, indicating under exploitation of *Serranus cabrilla* in the study area.

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

<table>
<thead>
<tr>
<th>Authors</th>
<th>Countries</th>
<th>Length-weight relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current study</td>
<td>Gulf of Annaba (Algeria)</td>
<td>TW = 0.008 TL$^{0.066}$</td>
</tr>
<tr>
<td>Gordo et al., 2016</td>
<td>Atlantic (Portuguese coast)</td>
<td>TW = 0.0097 TL$^{1.05}$</td>
</tr>
<tr>
<td>Oztekin et al., 2016</td>
<td>Aegean sea, Turkey</td>
<td>TW = 0.0164 TL$^{0.9}$</td>
</tr>
<tr>
<td>Akalin et al., 2015</td>
<td>Cendarli Bay, Turkey</td>
<td>TW = 0.0091 TL$^{0.9}$</td>
</tr>
<tr>
<td>Cengiz, 2013</td>
<td>Gallipoli, Turkey</td>
<td>TW = 0.0116 TL$^{0.3}$</td>
</tr>
<tr>
<td>Bök et al., 2011</td>
<td>Marmara Sea, Turkey</td>
<td>TW = 0.0091 TL$^{1.18}$</td>
</tr>
<tr>
<td>Çakir et al., 2008</td>
<td>Edremit bay, Turkey</td>
<td>TW = 7.10$^{-5}$ TL$^{2.62}$</td>
</tr>
<tr>
<td>Ismen et al., 2007</td>
<td>Saros bay, Turkey</td>
<td>TW = 0.0086 TL$^{1.06}$</td>
</tr>
<tr>
<td>Cicek et al., 2006</td>
<td>North East Mediterranean</td>
<td>TW = 0.0131 TL$^{3.89}$</td>
</tr>
<tr>
<td>Karakulak et al., 2006</td>
<td>Aegean sea, Turkey</td>
<td>TW = 0.0112 TL$^{2.99}$</td>
</tr>
<tr>
<td>Moutopoulos and Stergiou, 1998</td>
<td>Aegean sea, Turkey</td>
<td>TW = 0.0107 TL$^{3.001}$</td>
</tr>
<tr>
<td>Altin et al., 2015</td>
<td>Golfe d’Antalya, Turquie</td>
<td>TW = 0.012 TL$^{2.90}$</td>
</tr>
<tr>
<td>Kapiris and Klaoudatos, 2011</td>
<td>Aegean sea, Turkey</td>
<td>TW = 0.5. 10$^{-4}$ TL$^{2.71}$</td>
</tr>
<tr>
<td>Torcu-Koc et al., 2004</td>
<td>Edremit bay, Turkey</td>
<td>TW = 0.0311 TL$^{2.57}$</td>
</tr>
<tr>
<td>Abdallah, 2002</td>
<td>Alexandria, Egypt</td>
<td>TW = 0.039 TL$^{2.55}$</td>
</tr>
<tr>
<td>Moutopoulos and Stergiou, 2002</td>
<td>Aegean sea, Turkey</td>
<td>TW = 0.0186 TL$^{2.805}$</td>
</tr>
<tr>
<td>Torcu et al., 1998</td>
<td>Edremit bay, Turkey</td>
<td>TW = 0.0353 TL$^{2.61}$</td>
</tr>
<tr>
<td>Goncalves et al., 1997</td>
<td>Atlantic (Portuguese coast)</td>
<td>TW = 0.7. 10$^{-4}$ TL$^{2.66}$</td>
</tr>
<tr>
<td>Merella et al., 1997</td>
<td>Balearic Islands (Mediterranean)</td>
<td>TW = 0.016 TL$^{2.82}$</td>
</tr>
<tr>
<td>Petraitis and Stergiou, 1995</td>
<td>Greece</td>
<td>TW = 0.022 TL$^{3.92}$</td>
</tr>
<tr>
<td>Papaconstantinou et al., 1994</td>
<td>Aegean sea, Turkey</td>
<td>TW = 0.0276 TL$^{2.725}$</td>
</tr>
<tr>
<td>Ozvarol, 2014</td>
<td>Antalya gulf, Turkey</td>
<td>TW = 0.0091 TL$^{3.014}$</td>
</tr>
<tr>
<td>Sangan et al., 2007</td>
<td>North East Mediterranean</td>
<td>TW = 0.0662 TL$^{1.22}$</td>
</tr>
</tbody>
</table>
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’)).

<table>
<thead>
<tr>
<th>Authors</th>
<th>Regions</th>
<th>L∞ (cm)</th>
<th>K (year⁻¹)</th>
<th>ϕ’</th>
</tr>
</thead>
<tbody>
<tr>
<td>This study</td>
<td>Gulf of Annaba (Algeria)</td>
<td>24.94</td>
<td>0.38</td>
<td>2.37</td>
</tr>
<tr>
<td>Gordo et al., 2016</td>
<td>Portuguese coasts, Atlantic</td>
<td>25.26</td>
<td>0.21</td>
<td>2.13</td>
</tr>
<tr>
<td>Ilhan et al., 2010</td>
<td>Aegean Sea, Turkey</td>
<td>23.88</td>
<td>0.30</td>
<td>2.23</td>
</tr>
<tr>
<td>Torcu-Koc et al., 2004</td>
<td>Aegean Sea, Turkey</td>
<td>33.55</td>
<td>0.11</td>
<td>2.43</td>
</tr>
<tr>
<td>Tserpes and Tsimenides, 2001</td>
<td>Crete, Greece</td>
<td>22.39</td>
<td>0.38</td>
<td>2.28c</td>
</tr>
<tr>
<td>Tserpes, 1996</td>
<td>Cretan Sea</td>
<td>23.54</td>
<td>0.34</td>
<td>2.28c</td>
</tr>
<tr>
<td>Politou and Papaconstantinou,</td>
<td>Northern Greece</td>
<td>23.81</td>
<td>0.30</td>
<td>2.23</td>
</tr>
<tr>
<td>1995</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Papaconstantinou et al., 1994</td>
<td>Northern Greece</td>
<td>25.8</td>
<td>0.30</td>
<td>2.30c</td>
</tr>
<tr>
<td>Bouain, 1983</td>
<td>Tunisia</td>
<td>31.85</td>
<td>0.10</td>
<td>2.01c</td>
</tr>
</tbody>
</table>

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 (\(K = 0.1 \text{ year}^{-1}\)) and Gordo et al. (2016) in Atlantic (\(K = 0.21 \text{ year}^{-1}\)). It is theoretically admitted that growth parameters \(L_\infty\) and \(K\) are negatively correlated, when \(L_\infty\) 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 \((\phi')\) 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 Torçu-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 Tsimenides (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 \(E_{\text{opt}} = 0.5\). Contrary to where it was heavily exploited around Crete (Greece) (Tserpes and Tsimenides 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 (\(L_{50} = 16\) 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) (\(L_{50} = 13.2\) cm and \(L_{50} = 12.9\) 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 \(L_c/L_\infty\) 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 \(L_c/L_\infty\) 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**


