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# *Population of the Flathead Grey Mullet (Mugil cephalus, L. 1758) from the Bay of Burgas, Bulgarian Black Sea Coast*

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**Abstract.** The study is aimed to investigate the dynamics of age distribution, size structure and annual growth rates of *Mugil cephalus* from the Bay of Burgas. The species inhabits inshore marine waters, as well as estuaries, lagoons and rivers and has high economic importance. Only four age groups were determined for the recent period (2015-2018), compared to the previous period (2010 - 2013) when the flathead grey mullet population has eight age groups. For the period 2010-2013, the size classes ranged from 3.1 cm to 49 cm. For the period 2015-2018, the maximum total length registered was 27 cm. The equation describing the relationship between the length of the body and the radius of the scale is L=0.4177S + 0.376, $r^2$=0.9769. The von Bertalanffy's equation for length growth of the flathead mullet is $L_t$=139.8[1-$e^{-0.04(t+0.07)}$], $r^2$=0.9996 and for the weight growth is $W_t$ = 3139[1-$e^{-0.1723\ (t-0.372)}$]$^{3.0654}$, $r^2$=0.9328. The equation describing the length-weight relationship of *Mugil cephalus* is W=0.0122*$L^{3.0961}$, $r^2$=0.991. Values of Fulton's condition index for the age groups from 1 to 4 varied between 1.54 and 1.82. Comparison between the results obtained for the periods 2010-2013 and 2015-2018 shows deterioration of the population of the flathead grey mullet in the surveyed area.

**Key words:** population parameters, von Bertalanffy's equation, Fulton's condition index, Black Sea coast, *Mugil cephalus*.

## Introduction

Environmental changes due to anthropogenic factors affect all parts of the plant and animal world in inland waters, seas and oceans. The Black Sea is close to the so-called "red line" beyond which ecosystem degradation processes may become irreversible. Commercial fishing is the most unfavorable factor as it directly destroys a significant part of the populations of certain species, which in terms affects all other species that are in strictly specific relationships with the intensely exploited ones. The mullets as species with rapid growth rate are sensitive to various anthropogenic impacts and changes. The dynamics of the stocks of these species is highly dependent on both the size of catches and the changing ecological status of the Black Sea over the years (Prodanov et al., 1997).

The flathead grey mullet (*Mugil cephalus* L.) is cosmopolitan species occurring in tropical, subtropical and temperate coastal

waters in all major oceans (Quignard & Farrugio, 1981). This species occupies a wide variety of marine, estuarine and freshwater environments, but spawning occurs in the sea (Karapetkova & Zhivkov, 2006; Ghaninejad et al., 2010). As expected with the above distribution pattern, *M. cephalus* is a strongly euryhaline species capable of living in waters ranging from fresh to hyperhaline (Koutrakis, 2011; Minos et al., 1994). The flathead grey mullet is also found in both clear and turbid areas, sandy and muddy habitats, and can survive in waters with a wide range of dissolved oxygen levels (Minos et al. 1994; 1995).

The dynamics of stocks of *M. cephalus* is highly dependent on both the size of catches and the changing ecological status of the Black Sea over the years. The only published data on the grey mullet are its catches, growth and migrations of fishes from the Bulgarian Black Sea coast before 40-50 years (Alexandrova, 1957a; b; 1961; 1964; 1967; 1973). These peculiarities of the species and the lack of regular data on the status of its populations require specialized studies on its population parameters and stocks.

The current study is aimed to compare data for two periods in the age-size range of *M. cephalus*, as well as to evaluate new data on the Length-Weight growth of the species in the Bay of Burgas, as well as data on the Condition factor.

**Material and Methods**

*M. cephalus* specimens were collected during the period May 2010 – July 2018 from different areas of the Burgas Bay, Bulgarian Black Sea coast (Fig. 1). The fishing unit was a trammel net with a length of 50 m, a depth of 1,5 m and a stretched mesh size of 25 mm, set for 24 h. Trammel nets are less selective than gill nets (Perrow et al., 1996) and because of this they were used.

The length-weight growth, condition factor (K) was studied in 1359 specimens. Standard length (SL±1mm), total weight (TW±1g), gutted (somatic) weight (W±1g) were measured. The age was determined by the scales at a magnification of 17.5x with Projector Dokumator, Lasergeret (Carl Zeiss, Jena).

The mean lengths and weights were used to calculate the von Bertalanffy growth equations: $L_\infty$, $W_\infty$, k and $t_o$ (Growth II program, version 2.1.0.48).

The condition factor (K) was calculated by four ways:

I. Directly - as a coefficient *k* of the equation $W = aL^n$, as the parameters are determined separately for each age group and the whole population (Dikov & Zhivkov, 1985; Hyslop, 1987; Zhivkov & Raikova-Petrova, 1988), were W is a weight of the fishes, L is the length of fishes, *a* and *n* are coefficients;

II. By Fulton's classical formula: $K_f = (W/L^3)*100$, were W is the weight of the fishes, L – length of fishes;

III. According to Fulton's formula, using the exponent *n* of the formula $W = aL^n$, derived for the whole population or the respective age group (Dikov & Zhivkov, 1985; Zhivkov & Raikova-Petrova, 1988);

IV. By the values of the fish weights (W) at the same, randomly selected lengths, calculated by the equation $W = aL^n$. The population that has a higher value of W at the same value of L is considered to be fatter. (Basami & Grove, 1985; De Silva, 1985; Goldspink, 1979).

**Results and Discussion**

The main objective was to extend and deepen the knowledge of the population-biological characteristics of *M. cephalus*.

An analysis of the age composition of the caught ichthyologic material for the two periods 2010 – 2013 and 2015-2018 was made. (Fig. 2).

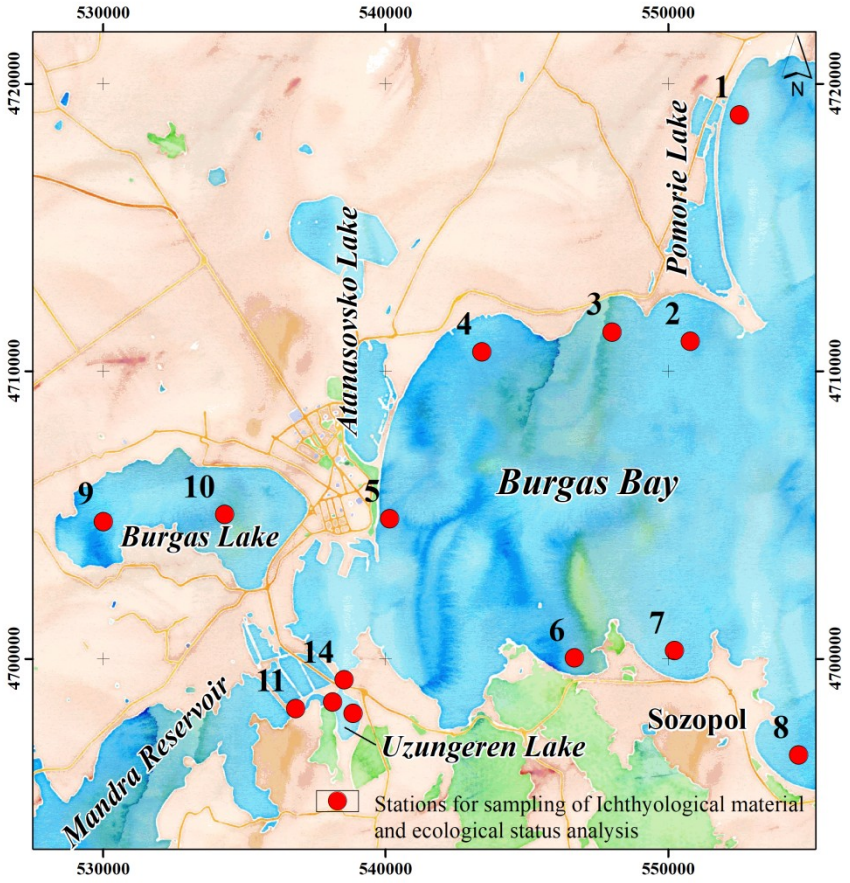


**Fig. 1.** Location of sampling sites along the Bay of Burgas, Bulgarian Black Sea coast.

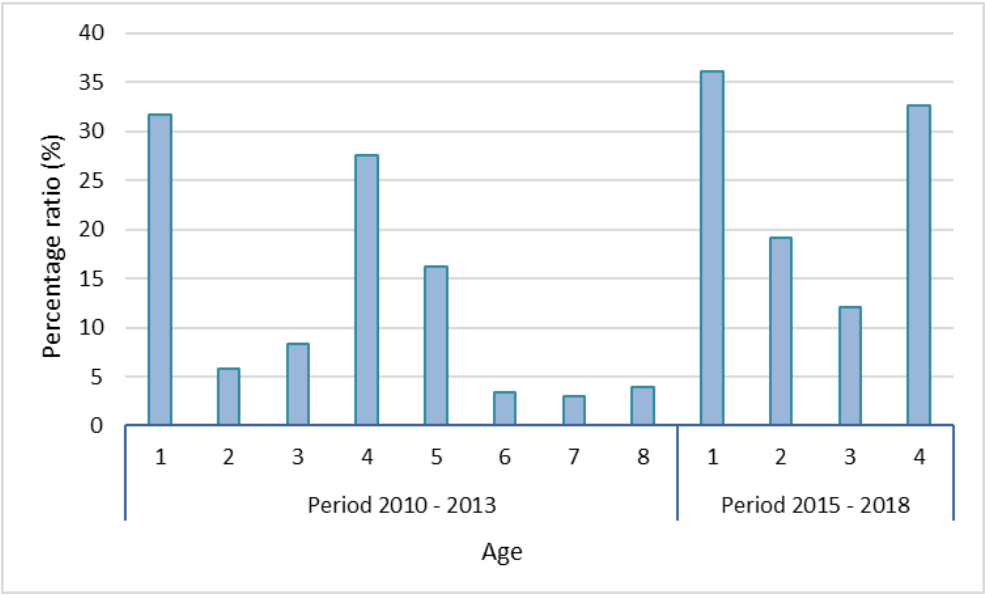


**Fig. 2.** Age distribution of *Mugil cephalus* from Burgas Bay for two periods.

Only four age groups were determined for the recent period (2015-2018), compared to the previous period (2010-2013) when the flathead grey mullet population has eight age groups.

The established age structure ranks the *M. cephalus* population among the populations with an average life cycle (with a maximum age of 8 to 12 years) (Quignard & Farrugio, 1981). The lower number of fish from large age groups, as well as the weighted average age, indicate the maintenance of a young population. For the period 2010-2013, the size classes ranged from 3.1 cm to 49 cm. For the period 2015-2018, the maximum total length registered was 27 cm (Fig. 3).

The reason for this is most likely the intensive fishing, which is aimed mainly at larger specimens (Bekova, 2020). Another factor that affects the population structure is the deteriorating food base (Bekova et al., 2013). The heavy pollution of some of the coastal areas, and in particular of our southern coast, should not be underestimated (Bekova et al., 2019).

According to von Bertalanffy's model, the asymptomatic length ($L_\infty$) is 139.8 cm (Fig. 4). The reason for this result is the low value of the growth factor k - 0.04, indicating a meager rate of growth of the individuals in the population. Low values we get for k explain the higher values we get for $L\infty$ since two parameters are inversely related - the smaller the value of the integer k, the greater are the values of $L_\infty$ (Ricker, 1975). For the *M. cephalus* Alexandrova (1957a) received values for $L_\infty$ - 69.1 cm, at k = 0.416 and $t_0$ = 0.0843. In comparing asymptotic to the maximum observed in our capture length (Lmax = 48,7 cm) Lmax:$L_\infty$ gives little value 0.24. This indicates that according to the methodology of Hohendorf (1966) the population of *M. cephalus* in the region not used enough growth potential.

Obtaining higher levels of $L_\infty$ and accordingly, lower values of k are usually observed in populations with a low initial length and slower growth rate.

The asymptotic average weight ($W_\infty$) that we get to flathead mullet from the Bulgarian Black Sea coast is 3139 g (Fig. 5). By comparing this value to the maximum set in our catches (Wmax=1800 g), we obtain 0.6 by Wmax:$W_\infty$ of Hohendorf (1966). Again here, it is confirmed that the population does not fully exploit its growth potential.

As with linear growth, high values for $W_\infty$ and shallow k values are most likely due to the low weight of fish in the first year and the process of self-regulation of growth.

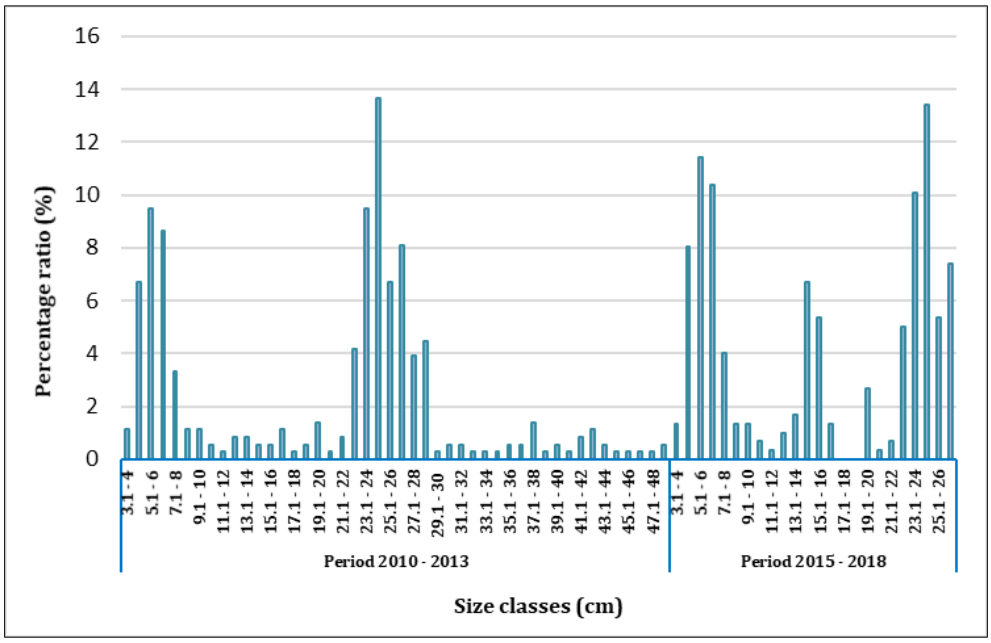


**Fig. 3.** The size structure of *Mugil cephalus* from the Bay of Burgas for two periods.

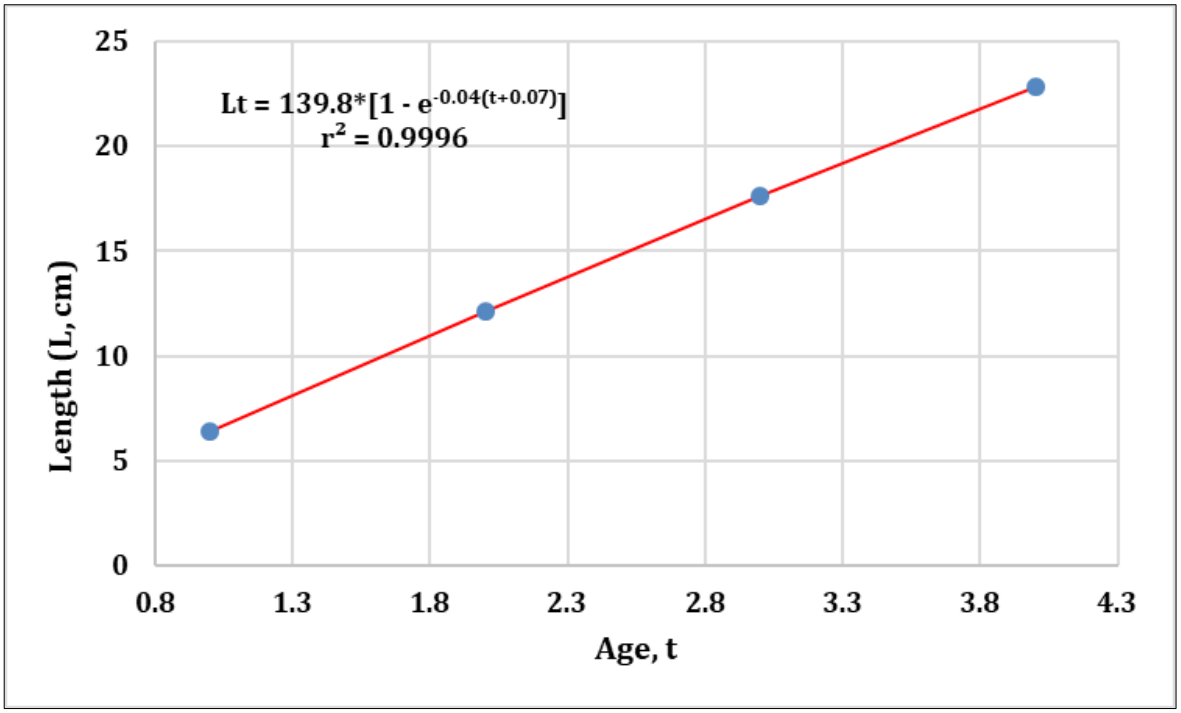


**Fig. 4.** The von Bertalanffy's equation for length growth of the *M. cephalus* from the Bay of Burgas for the period 2015 – 2018.

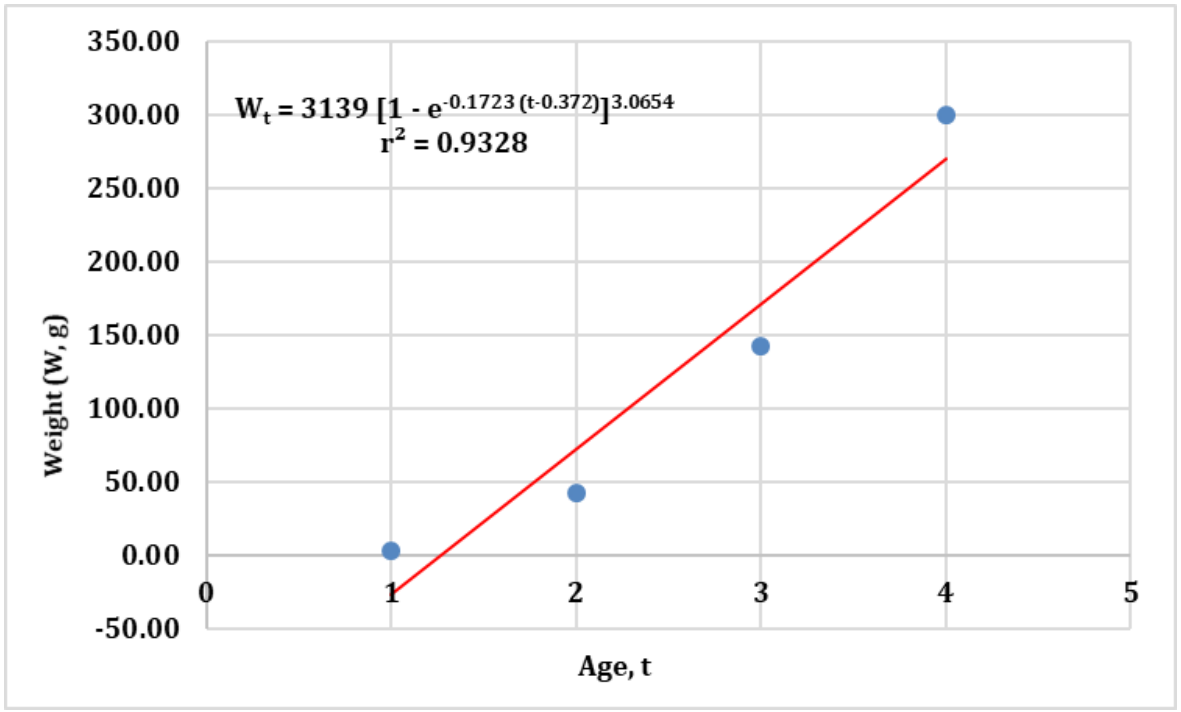


**Fig. 5.** The von Bertalanffy's equation for weight growth of the *M. cephalus* from the Burgas Bay for the period 2015 – 2018.

It was established that 90% of the habitat of mullet fish in the Usungeren Lake is already located at depths below 1 m (Fig. 6). These conditions are no longer suitable for wintering of these species but are suitable for their conservation. The results are based on the first bathymetric model of the lake and analysis of structural changes that have occurred, resulting in a decrease in depths and areas compared to the 1960s. Juveniles spend their first year in conditions varying from fresh water to seawater, and, over a period of 48 hours, fish of 20-30 mm standard length can survive transfer from seawater to fresh water, and, by 40-69 mm, salinity tolerances and osmotic regulatory capacities are fully developed (Harison, 2003; Prodanov et al., 1997). Adults tolerate wide ranges in salinity, from freshwater to hypersaline conditions (0-126‰) and temperature from 5-37°C (Harison, 2003). This in our climate zone shows that shallow waters are not suitable for wintering species such as mullets, which do not tolerate low water temperatures during the winter.

Table 1 represents the conditional factor of *M. cephalus* from the Burgas Bay: by the classical equation of Fulton $K_f=W/L^3$, by its modification $K_n=W/L^n$, by $K_a=a$ from the equation $W=aL^n$ and by the mass calculated by the same equation at randomly chosen equal lengths. The last method is the most accurate because it takes into account the differences in the growth rate during different periods of life. The values of Fulton's condition index for the age groups from 1 to 4 varied between 1.54 and 1.82. The results show that the studied population does`t optimal conditions to growth.

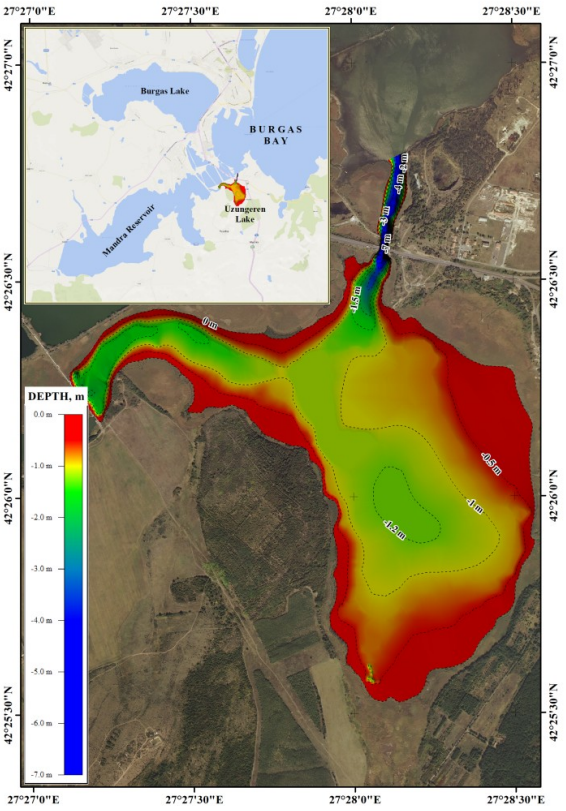


**Fig. 6.** Bathymetric map of the Uzungeren Lake (Burgas Bay).

**Table 1.** The conditional factor of *M. cephalus* by age groups from the Bay of Burgas.

| Condition factor (K) | | | |
|---|---|---|---|
| $W=aL^b$ | $K_a$ | $K_n$ | $K_f$ |
| $W_1=0.0238L_1^{2.7544}$ | 2.4 | 2.9 | 1.81 |
| $W_2=0.0423L_2^{2.5885}$ | 4.2 | 4.7 | 1.54 |
| $W_3=0.0117L_3^{3.1371}$ | 1.2 | 1.2 | 1.80 |
| $W_4=0.0143L^{3.0752}$ | 1.4 | 1.4 | 1.82 |

**Conclusions**

Comparison between the results obtained for the periods 2010-2013 and 2015-2018 shows the deterioration of the population of the flathead grey mullet. For the recent period (2015-2018) only four age groups were determined, compared to the previous period (2010 - 2013) when the flathead grey mullet population has eight age groups. For the period 2010-2013, the size classes ranged from 3.1 cm to 49 cm. For the period 2015-2018, the maximum total length registered was 27 cm. The lack of certain age and size classes for the period 2015-2018 compared to 2010-2013 speaks for worsening environmental conditions and the intensive fishing press, leading to a sharp decline in the populations of mullets. Our

results show that the population of grey mullet is characterized by slow growth, most likely due to the deteriorating living conditions and the early age of maturation. The results showed that the species not used enough growth potential for their populations.

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