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# GROWTH, CONDITION AND POPULATION INSIGHTS OF *Mesogobius batrachocephalus* IN THE ROMANIAN BLACK SEA

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***Abstract***

*Understanding the ecology and population dynamics of Mesogobius batrachocephalus along the Romanian Black Sea coast is essential due to limited available data. This study examined population structure, growth, and condition based on 248 individuals (183 females, 65 males), revealing a female-biased sex ratio of 2.82:1. Morphometric measurements (total length, TL; body weight, W) were collected, and Fulton's condition factor (K) was calculated. TL ranged from 11.5 to 32.4 cm (mean ± SD: 24.06 ± 3.44 cm) and W from 26.22 to 287 g (131.68 ± 50.64 g). K varied between 0.61 and 1.86 (mean ± SD: 0.92 ± 0.17). The length–weight relationship was* $W = 0.0457 \times TL^{2.4882}$ *(*$r^2 = 0.8521$*). Von Bertalanffy parameters were* $L\infty = 34.11$ *cm,* $K = 0.370$*, and* $t_0 = -0.355$*. Mortality estimates were* $Z = 1.34$*,* $M = 0.63$*, and* $F = 0.71$*. These findings provide essential baseline information for monitoring and managing M. batrachocephalus populations in the western Black Sea.*

***Key words****: condition factor, Knout goby, length-weight analysis, population dynamics, Von Bertalanffy growth.*

## INTRODUCTION

The knout goby *Mesogobius batrachocephalus* (Pallas, 1814) is a demersal gobiid widely distributed in the Black Sea, Sea of Azov, and eastern Mediterranean, inhabiting shallow coastal waters with sandy, muddy, or mixed substrates. Along the Romanian coast, Gobiidae represent one of the most diverse benthic fish groups, with over 15 species reported, several of local ecological or commercial interest (Bănaru et al., 2017). Recent taxonomic revisions revealed considerable species-level diversity within morphologically similar gobies (Vasil'eva, 2025), while morphometric studies across the Azov–Black Sea basin have documented pronounced spatial variability within gobiid populations, emphasizing the influence of regional environmental conditions (Belogurova, 2024). These findings highlight the need for species-specific studies of growth and population dynamics. *M. batrachocephalus* is among the largest gobiids, exceeding 30 cm total length, historically captured in artisanal fisheries and as by-catch (Roșca & Mânzu, 2011), and also recorded in experimental coastal gear, including round goby traps (Țiganov et al., 2023). Bulgarian Black Sea catches show that gobies are the second most important fish group after sprat, demonstrating ecological and commercial relevance (Zarev et al., 2013).

Previous studies along the Romanian coast focused on feeding ecology and seasonal diet variation. *M. batrachocephalus* shows an opportunistic benthic diet dominated by crustaceans, polychaetes, and small fishes, with seasonal shifts linked to prey availability (Roșca & Mânzu, 2011). Other benthic fish studies confirm a generalist feeding strategy based on macrobenthic fauna (Roșca & Surugiu, 2010). Morphological analyses, including otolith shape, revealed distinctive sagittal otolith morphotypes in *M. batrachocephalus*, useful for trophic studies and interspecific differentiation (Bănaru et al., 2017). Recent morphometric and

genetic work confirms clear separation from sympatric gobiids (Karadurmuş et al., 2024).

In other Black Sea regions, studies examined growth, condition, reproduction, and length–weight relationships. Bengil & Aydın (2020) reported sex and habitat-related variations in length–weight parameters, condition factor, and feeding patterns, while Aydın (2021) provided detailed biometric assessments of growth and population parameters. Although not a major commercial species, *M. batrachocephalus* is periodically caught in coastal traps and gillnets, with variable biomass contribution depending on year and location (Bengil & Aydın, 2020; Aydın, 2021; Țiganov et al., 2023). Long-term, species-specific datasets along the Romanian coast remain scarce, with fluctuations in catches influenced by environmental and ecological factors.

Given limited updated data for Romania on growth, length–weight relationships, monthly biological variation, and sex-specific condition, this study provides an integrated assessment of *M. batrachocephalus* using recent data. Biometric characteristics, condition indices (including Fulton's K), sex ratio, length-frequency structure, and population parameters are analysed to improve understanding of the species status and provide a baseline for future ecological and fisheries research.

## MATERIALS AND METHODS

Specimens of *Mesogobius batrachocephalus* were collected along the Romanian Black Sea coast (Baia Mamaia, across Port Tomis, across Port Constanta and the Tuzla-Costinesti area, at depths between 3 and 25 m) as part of the National Fisheries Data Collection Program conducted by NIMRD "Grigore Antipa". Sampling locations were mapped in ArcGIS (Figure 1).

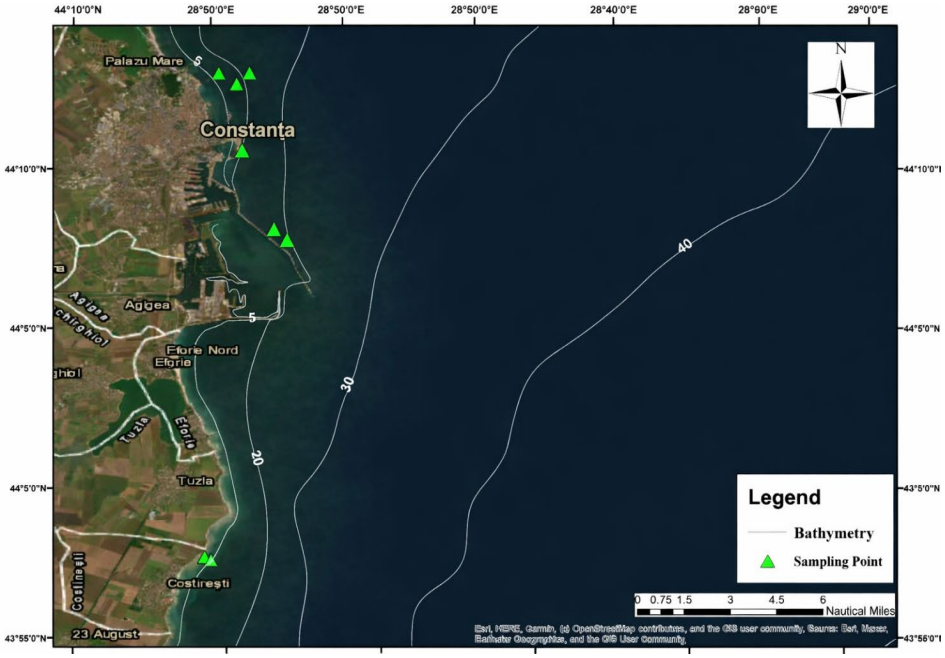


Figure 1. Sampling map (Alexandru Cândescu, NIMRD "Grigore Antipa")

Specimens were captured using 50 round goby traps deployed each month (March, April, September, October, November 2025). Chicken meat was used as attractant. Captured fish were removed from traps and transported to the laboratory in insulated containers, where biometric measurements were performed. In the laboratory, total length (TL, ± 1 mm), total weight (W, ± 0.1 g), and additional morphometric traits were recorded, with photographic documentation (Figure 2).



Figure 2. Total length (TL) measurements of *Mesogobius batrachocephalus* individuals in the laboratory (original by NIMRD)

The length-weight relationship was estimated using the allometric equation (Froese, 2006):

$$W = a \cdot TL^b \qquad (1)$$

with log-transformed linear regression:

$$\log W = \log a + b \cdot \log TL \qquad (2)$$

Fulton's condition factor was calculated as:

$$K = \frac{W}{TL^3} \cdot 100 \qquad (3),$$

following Fulton (1904) and Froese (2006).
Population structure was analyzed using FiSAT II – FAO ICLARM Stock Assessment Tool (Gayanilo et al., 2005) to determine length-frequency distributions, growth parameters ($L\infty$, K), mortality rates (total, natural, fishing), and sex ratio. Additional analyses, including descriptive statistics, t-tests for sex- and month-related differences, and TL-W correlations (Pearson), were performed in Microsoft Excel 365 and XLSTAT (2025.1.3). Graphs generated in Excel included lnTL vs lnW scatterplots, length-frequency distributions, and boxplots of TL, W, and Fulton's K by sex and month.

## ETHICAL STATEMENT

Fish were collected through scientific sampling as part of the National Fisheries Data Collection Program conducted by the National Institute for Marine Research and Development "Grigore Antipa". No experimental procedures were performed on live animals. The study was based on specimens obtained from scientific fisheries sampling in accordance with national regulations.

## RESULTS AND DISCUSSIONS

A total of 248 *Mesogobius batrachocephalus* individuals were collected from March to November 2025 using round goby traps. Total lengths ranged from 11.5 to 32.4 cm and weights from 26.22 to 287 g, with mean TL 24.06 cm and mean W 131.68 g, indicating a population composed of juveniles and adults (Table 1).
When separated by sex, females were slightly larger and heavier than males, consistent with typical gobiid sexual dimorphism. Maximum values were also higher in females, reflecting their reproductive role.
Sex composition was strongly female-biased (183 females, 65 males; F:M ≈ 2.82:1, 73.8 % females) (Figure 3), comparable to Bănaru et al. (2017, ~2:1) in the northwestern Black Sea. In contrast, southern Black Sea populations show near parity (Aydın, 2021; Bengil & Aydın, 2020). Female predominance may reflect differences in reproductive lifespan, spawning mortality, spatial distribution, or pot selectivity, indicating a population in a stable reproductive phase.

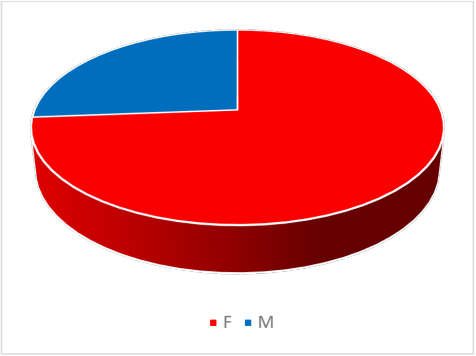


Figure 3. Sex ratio of *Mesogobius batrachocephalus* (original)

Table 1. Descriptive statistics of total length (TL) and weight (W) by sex and overall

| Group | N | TL mean | TL SD | TL min | TL max | W mean | W SD | W min | W max |
|---|---|---|---|---|---|---|---|---|---|
| Total | 248 | 24.06 | 3.44 | 11.5 | 32.4 | 131.68 | 50.64 | 26.22 | 287 |
| F | 183 | 24.03 | 3.42 | 11.5 | 32.4 | 131.26 | 50.19 | 26.22 | 287 |
| M | 65 | 23.96 | 3.46 | 12 | 31 | 131.68 | 50.99 | 26.3 | 246.91 |

Length-frequency analysis shows most individuals in the 22-28 cm range, with minor peaks at 11-20 cm and 31-32 cm (Figure 4), reflecting multiple cohorts. The distribution is slightly left-skewed, suggesting fewer large specimens. The main peak (25-28 cm) represents the dominant size class, while smaller peaks correspond to juveniles. This structure indicates ongoing recruitment and reproductive potential.

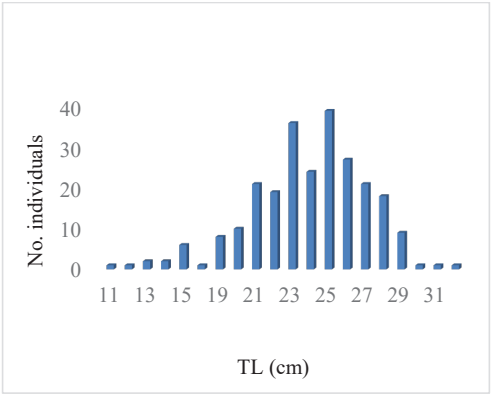


Figure 4. Length - frequency (both sexes)

Overall, the population exhibits a wide size range, female-biased sex ratio, and multiple cohorts, confirming active reproduction and a healthy demographic structure, providing the basis for subsequent growth and condition analyses.

**Length-Weight Relationship (LWR)**

The length-weight relationship of *Mesogobius batrachocephalus* was analysed to assess growth patterns and population condition, and to compare with previous studies. The overall LWR showed negative allometric growth ($b = 2.4882$; $R^2 = 0.8521$), indicating that weight increases more slowly than length (Figure 5). This aligns with findings from Demirhan & Can (2007), Demirhan et al. (2005), Ak et al. (2009), and Çalık & Erdoğan Sağlam (2017), who also reported $b < 3.0$ in various Black Sea populations (Table 2). Negative allometry suggests energy allocation toward reproduction or maintenance rather than somatic growth (Ricker, 1973; 1975; Weatherley & Gill, 1987; Froese, 2006).

Some studies report isometric growth ($b \approx 3$) (Păun, 2024) or positive allometry ($b > 3$) (Dağtekin et al., 2022; Bengil & Aydın, 2020; Aydın, 2021), highlighting regional variability due to environmental conditions, productivity, or sampling season. The negative allometric

growth observed in the present study (b = 2.4882) differs from several studies in the southern Black Sea where positive allometry was reported (b > 3). This difference may be explained by environmental and seasonal factors, including lower food availability, temperature differences, reproductive investment, and sampling period. The specimens in this study were collected mainly during spring and autumn, periods associated with gonadal development and energy allocation toward reproduction rather than somatic growth. Additionally, habitat conditions along the Romanian coast, including substrate type, productivity, and fishing pressure, may influence growth patterns and result in lower b values compared to other Black Sea regions. Such regional variability in length–weight parameters is common in benthic species and reflects environmental plasticity rather than population decline. Females exhibited negative allometry (b = 2.5128; $R^2$ = 0.8441) and males similarly (b = 2.3911; $R^2$ = 0.862) (Figures 5-7). The lnW–lnL regression confirmed linearity of the relationship, showing a clear positive correlation between body weight (lnW) and total length (lnL) (Figure 8). Low scatter around the regression line indicates consistent growth patterns within the population, while outliers likely reflect individual variability related to age, nutritional status, or reproductive stage.

The predominance of negative allometric growth in both sexes suggests a growth strategy characterized by body elongation rather than proportional mass increase, a pattern commonly observed in benthic and demersal gobiid species. Such growth dynamics may represent adaptive responses to habitat structure, variable food availability, or increased energetic investment in gonadal development, particularly during reproductive periods. Similar growth strategies have been reported for gobiid fishes inhabiting shallow coastal environments, where environmental variability influences somatic growth trajectories. The consistency of negative allometry across sexes and size classes indicates a relatively homogeneous growth response within the studied population, despite seasonal environmental fluctuations. This stability enhances the applicability of the derived length-weight parameters for biomass estimation and population monitoring. Therefore, the LWR parameters obtained in the present study provide a robust baseline for interpreting Fulton's condition factor (K) and for use in fisheries-independent assessments and comparative ecological studies.

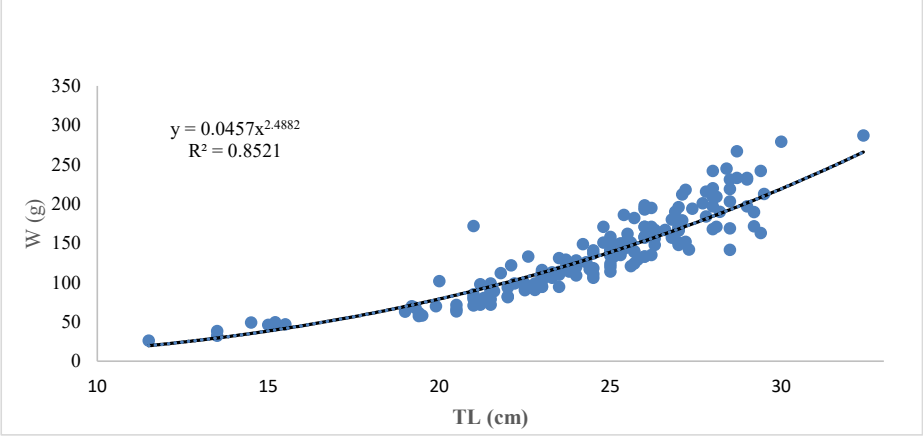


Figure 5. Length-weight relationship for all individuals

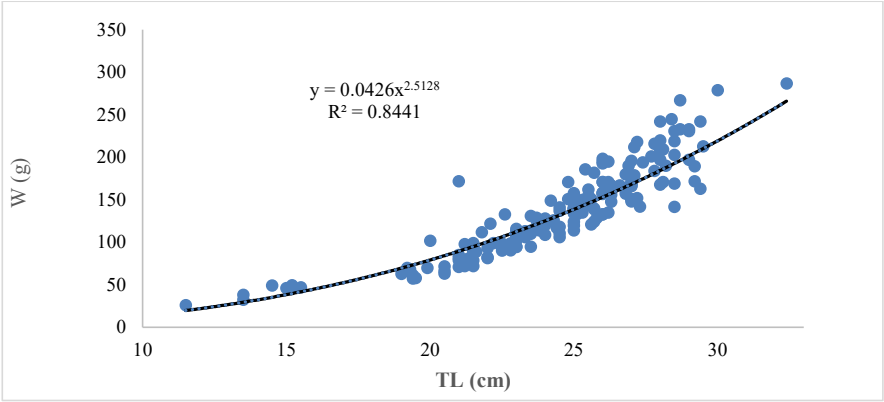


Figure 6. Length-weight relationship for females

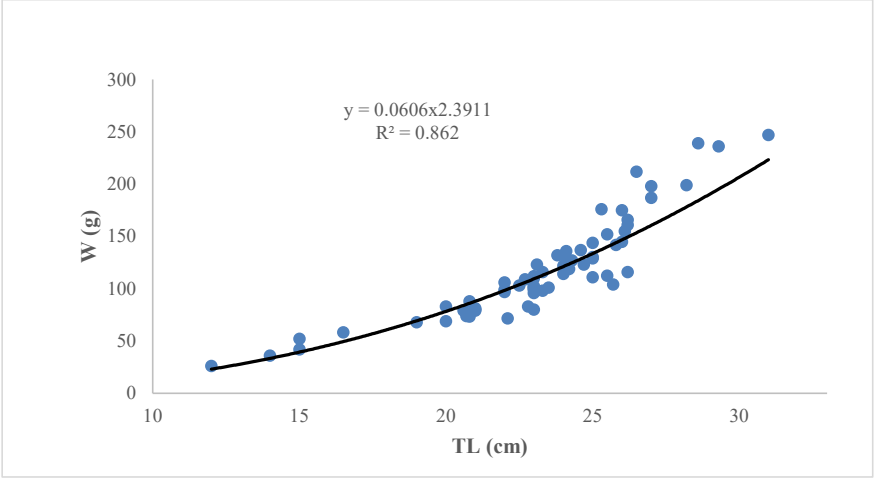


Figure 7. Length-weight relationship for males

Table 2. Previous literature indicating the result of length-weight relationship for round goby in different area

| Species | L (min.-max.) | W (min.-max.) | n | a | b | r2 | Growth type | Area | References |
|---|---|---|---|---|---|---|---|---|---|
| M. *batrachocephalus* | 7.2-13.3 | - | 37(C) | 0.0203 | 2.75 | 0.93 | A- | South-eastern Black Sea | Demirhan & Can (2007) |
| | 7.2-13.3 | 4-25.7 | 40(C) | 0.0289 | 2.6 | 0.88 | A- | South-eastern Black Sea | Demirhan et al. (2005) |
| | 12.6-31.8 | 12.62-377.54 | 470(C) | 0.0062 | 3.13 | 0.9606 | A+ | Southern Black Sea | Bengil & Aydın, (2020) |
| | 7.4-26.7 | 4.22-195.78 | 141 © | 0.0055 | 3.1566 | 0.9743 | A+ | South-eastern Black Sea | Dağtekin et al. (2022) |
| | 5.3-34 | 1.34-377.54 | 641(C) | 0.0058 | 3.148 | 0.9621 | A+ | Southern Black Sea | Aydın (2021) |
| | 5.5-18.0 | 1.71-77.0 | 184(C) | 0.024 | 2.736 | 0.913 | A- | Eastern Black Sea | Ak et al. (2009) |
| | 12.2-23.5 | 14.0-120.0 | 35(C) | 0.0149 | 2.7768 | 0.92 | A- | South-Central Black Sea | Çalık & Erdoğan Sağlam (2017) |
| | 19.0-29.3 | 68.0-242.0 | 46(C) | 0.0093 | 2.9981 | 0.8856 | I | Black Sea | Păun et al. (2024) |
| | 11.5-32.4 | 26.22-287 | 248(C) | 0.0457 | 2.488 | 0.8521 | A- | Black Sea | Present study |

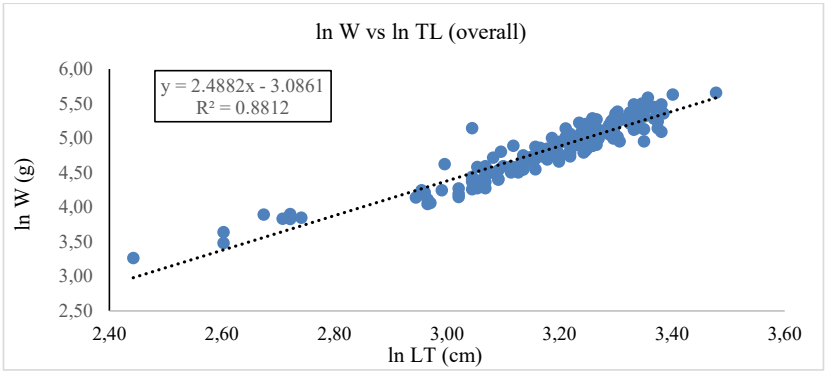


Figure 8. lnW–lnTL relationship (all data)

**Condition Factor (Fulton's K)**

Fulton's condition factor (K) was calculated following Fulton (1904) and Froese (2006) to assess body condition and energy allocation. The mean K for the population was 0.92 (range 0.61-1.86), indicating generally healthy individuals with moderate robustness (Table 3).

Table 3. Fulton's condition factor (K) by sex and overall

| Group | N | Mean K | SD K | Min K | Max K |
|---|---|---|---|---|---|
| Total | 248 | 0.92 | 0.17 | 0.61 | 1.86 |
| F | 183 | 0.92 | 0.17 | 0.61 | 1.86 |
| M | 65 | 0.93 | 0.17 | 0.61 | 1.54 |

Males and females showed similar mean K values (0.92 and 0.92, respectively), though females reached slightly higher maxima, likely reflecting gonadal development. Comparable K values (0.85-1.05) have been reported in other Black Sea populations (Çalık & Erdoğan Sağlam, 2017; Bengil & Aydın, 2020), supporting the interpretation of a healthy population.

Monthly comparisons of TL, W, and K showed no significant sex differences for most months ($p > 0.05$), except in October, where weight and K differed ($p < 0.001$), possibly reflecting autumnal variation in energy allocation prior to winter (Table 4). Similar patterns have been observed in other gobiids (Kornis et al., 2012). These differences likely relate to physiological processes rather than absolute size differences, as sex- and season-specific data for *M. batrachocephalus* are limited.

Table 4. Monthly comparison of TL, W and K between females and males of *M. batrachocephalus*

| Month | Variable | Mean F ± SD | N F | Mean M ± SD | N M | p-value | Significance |
|---|---|---|---|---|---|---|---|
| March | TL | 24.17± 3.14 | 30 | 21.53±1.35 | 5 | 0.14 | ns |
| March | W | 121.18±47.05 | 30 | 79.46±16.25 | 5 | 0.09 | ns |
| March | K | 0.82±0.10 | 30 | 0.79±0.06 | 5 | 0.43 | ns |
| April | TL | 20.76±4.33 | 36 | 21.24±4.46 | 14 | 0.77 | ns |
| April | W | 88.71±38.56 | 36 | 95.6±46.53 | 14 | 0.29 | ns |
| April | K | 0.99±0.28 | 36 | 0.99±0.27 | 14 | 0.48 | ns |
| September | TL | 23.99±2.16 | 25 | 23.93±2.07 | 7 | 0.13 | ns |
| September | W | 122.88±31.57 | 25 | 121.73±31.46 | 7 | 0.09 | ns |
| September | K | 0.88±0.1 | 25 | 0.87±0.09 | 7 | 0.87 | ns |
| October | TL | 24.12±2.47 | 46 | 24.06±2.51 | 18 | 0.0003 | * |
| October | W | 128.72±38.03 | 46 | 128.21±38.88 | 18 | 0.0001 | * |
| October | K | 0.90±0.14 | 46 | 0.91±0.14 | 18 | 0.72 | ns |
| November | TL | 24.91±2.42 | 46 | 24.96±2.44 | 21 | 0.08 | ns |
| November | W | 144.81±45.21 | 46 | 145.71±45.59 | 21 | 0.02 | ns |
| November | K | 0.91±0.12 | 46 | 0.91±0.12 | 21 | 0.01 | ns |

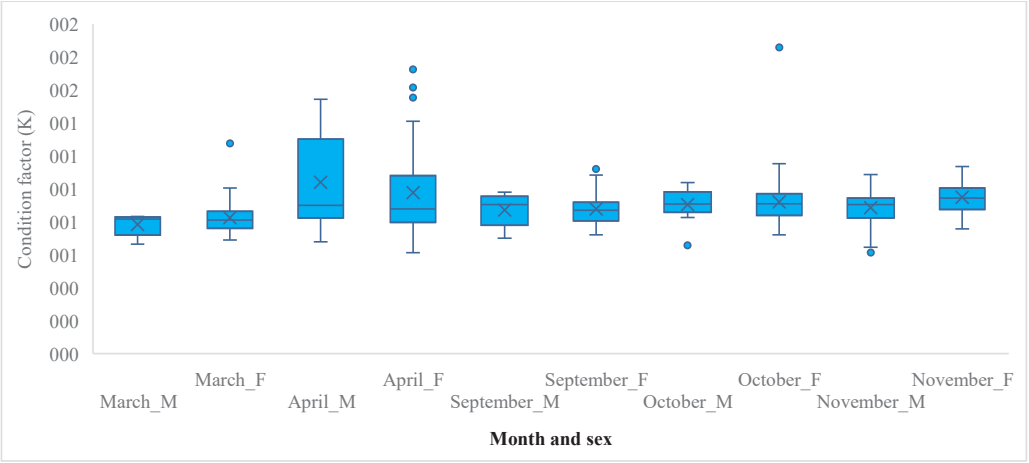


Figure 9. Boxplots of Condition factor (K) in *M. batrachocephalus* by Month and Sex

Boxplots of monthly K values (Figure 9) show largely overlapping interquartile ranges between sexes, indicating comparable physiological status. Slightly higher median K in females in March and October supports the interpretation of similar overall condition. These K patterns provide context for interpreting growth and mortality estimates in subsequent analyses.

These patterns in Fulton's K provide essential context for interpreting growth dynamics and mortality estimates examined in the following sections.

**Size Structure and Monthly Variation**

Boxplots of total length (TL) and weight (W) by month and sex (Figures 10-11) show that females generally have slightly higher TL and W values and wider ranges than males, although most differences were not statistically significant ($p > 0.05$). Males displayed narrower distributions with fewer extreme values. Weight patterns mirrored TL, with substantial overlap between sexes, indicating similar environmental and nutritional conditions. Female variability likely reflects reproductive cycle and seasonal gonadal development.

Fulton's condition factor (K) was stable across months, with comparable values between sexes and minor fluctuations (slightly higher in females in March and October), suggesting consistent physiological condition and energy allocation. Minimal outliers confirm population stability.

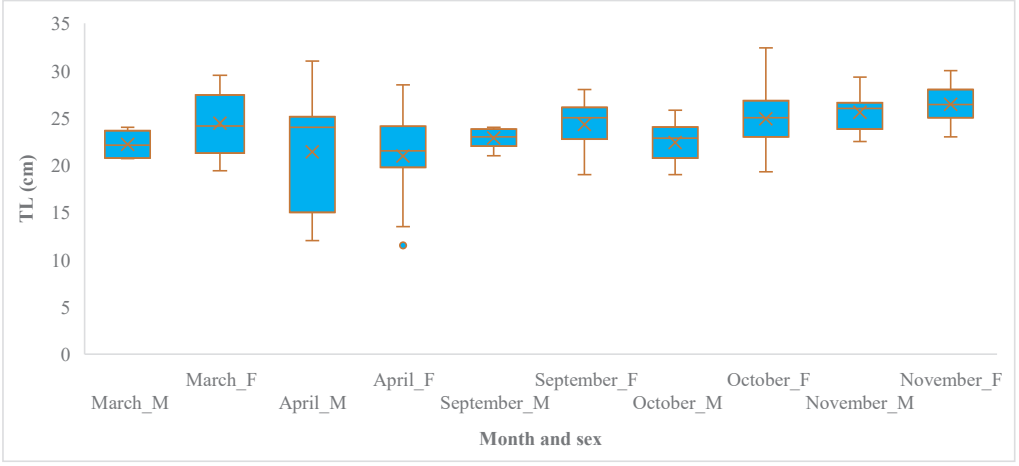


Figure 10. Boxplots of Total Length (TL) in *M. batrachocephalus* by Month and Sex

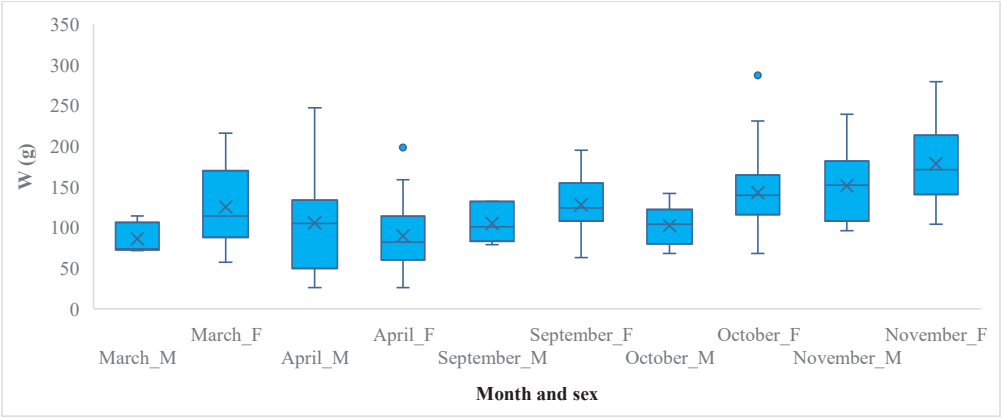


Figure 11. Boxplots of Weight (W) in *M. batrachocephalus* by Month and Sex

These monthly trends complement descriptive statistics and sex ratio patterns, providing a clear overview of population structure and a foundation for interpreting growth parameters, recruitment timing, and mortality in subsequent analyses.

**Mortality and Growth Analysis**

The length-converted catch curve highlights size at full recruitment, showing that smaller individuals are underrepresented due to gear selectivity (Figure 12). The descending slope indicates higher cumulative mortality in larger fish, reflecting moderate to high fishing or natural mortality, typical for benthic species.

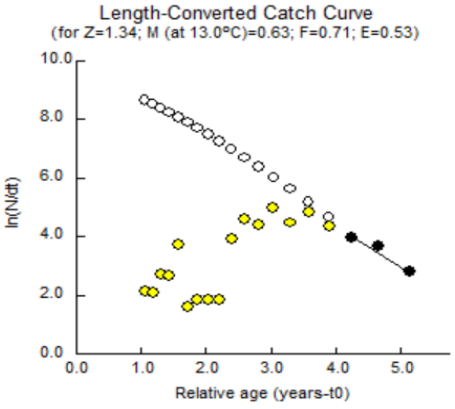


Figure 12. Length - Converted Catch Curve for *M. batrachocephalus*

The probability-of-capture (selectivity) curve shows low catchability for the smallest length classes, with Lc50 marking the size at 50% vulnerability (Figure 13). The steep curve indicates a narrow selectivity window, validating mortality and growth analyses based on larger size groups.

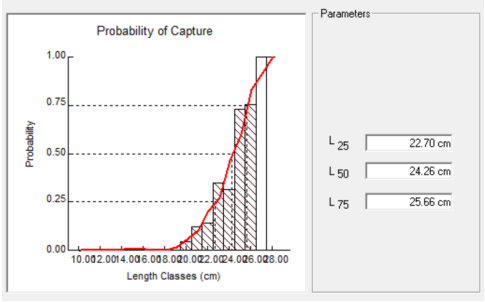


Figure 13. Probability of Capture in *M. batrachocephalus* (Lc50)

K-scan analysis identified a clear optimal von Bertalanffy growth coefficient (K), supporting a single dominant growth pattern (Figure 14). The von Bertalanffy model yielded an asymptotic length $L\infty \approx 34.11$ cm and $K \approx 0.370$ year$^{-1}$, placing the species in a moderate-growth category typical of demersal gobies. The derived Φ' index confirms biologically reasonable growth and allows comparison with other populations.

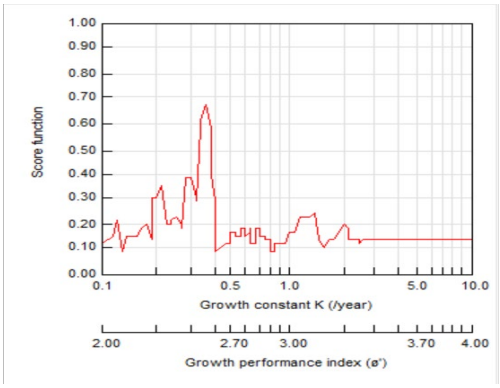


Figure 14. Growth Coefficient Distribution (K-Scan)

Comparison with Aydın (2021) from the southern Black Sea shows $L\infty = 38.2$ cm and $K = 0.245$ year$^{-1}$, with positive allometric growth ($b \approx 3.15$), contrasting with the negative allometry ($b \approx 2.4882$) observed here. Romanian coast populations grow faster initially but reach smaller maximum sizes, while southern populations grow slower to larger lengths. Fulton's condition factor is similar (~0.92 vs. ~0.913), indicating comparable energy reserves. Mortality estimates here indicate moderate to high pressure on larger individuals, a parameter not reported by Aydın (2021).

These results suggest that spatial variation, environmental factors, seasonality, and local exploitation influence growth patterns and maximum size. The estimated parameters provide a reliable basis for understanding *M. batrachocephalus* ecology along the Romanian coast and inform future monitoring and management.

## CONCLUSIONS

The population of *Mesogobius batrachocephalus* along the Romanian coast exhibits a good physiological condition, active recruitment, and a relatively stable population structure.

Growth is characterized by negative allometry and a moderate asymptotic length, with rapid growth during early life stages.

Females predominate in the population, while monthly variations are minor and no significant differences were detected between sexes.

The results suggest the existence of spatial variability in growth patterns within the Black Sea, whereas condition factors appear to remain relatively stable.

These findings provide baseline information for population monitoring, contribute to fisheries management considerations, and emphasize the importance of accounting for spatial and seasonal variability when assessing the ecological dynamics of this species.

Future research should focus on broader temporal and spatial analyses to further refine management and conservation strategies for *M. batrachocephalus* in the Black Sea.

## ACKNOWLEDGEMENTS

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## REFERENCES

Ak, O., Kutlu, S., & Aydın, İ. (2009). Length-weight relationship for 16 fish species from the Eastern Black Sea, Turkey. *Turkish Journal of Fisheries & Aquatic Sciences*, *9*, 125–126.

Aydın, M. (2021). The first data on the population parameters and morphometry of *Mesogobius batrachocephalus* (Pallas 1814) (Family: Gobiidae) in the southern Black Sea. *Aquatic Research*, *4*(2), 116–128. https://doi.org/10.3153/AR21009

Bănaru, D., Morat, F., & Crețeanu, M. (2017). Otolith shape analysis of three gobiid species of the Northwestern Black Sea. *Cybium*, *41*(4), 325–333. https://doi.org/10.26028/CYBIUM/2017-414-003

Belogurova, R. (2024). Morphometric variability in the round goby *Neogobius melanostomus* (Pallas, 1814) of the Sea of Azov–Black Sea Basin. *Marine Biological Journal*, *9*(1), 3–17.

Bengil, E. G. T., & Aydın, M. (2020). The length and weight relationships and feeding ecology of knout goby, *Mesogobius batrachocephalus* (Pallas, 1814) from Southern Black Sea. *Ege Journal of Fisheries and Aquatic Sciences*, *37*(4), 409–414. https://doi.org/10.12714/egejfas.37.4.12

Çalık, S., & Erdoğan Sağlam, N. (2017). Length-weight relationships of demersal fish species caught by bottom trawl from Eastern Black Sea (Turkey). *Cahiers de Biologie Marine*, *58*, 485–490. https://doi.org/10.21411/CBM.A.AA0D91E6

Dağtekin, M., Genç, Y., Kasapoğlu, N., Erik, G., Misir, D. S., İlhan, S., Ok, M., Altuntaş, C., Özsandikçi, U., Büyükdeveci, F., Kaya, T., Cebeci, A., Saltan, A. N., Haşimoğlu, A., & Firidin, Ş. (2022). Length weight

relationships of 28 fish species caught from demersal trawl survey in the Middle Black Sea, Turkey. *Turkish Journal of Zoology*: *Vol. 46: No. 1, Article 3.* https://doi.org/10.3906/zoo-2109-21 Available at:https://journals.tubitak.gov.tr/zoology/vol46/iss1/3

Demirhan, S. A., & Can, M. F. (2007). Length–weight relationships for seven fish species from the southeastern Black Sea. *Journal of Applied Ichthyology, 23*(3), 282-283. https://doi.org/10.1111/j.1439-0426.2007.00835.x

Demirhan, S. A., Seyhan, K., Engin, S., & Mazlum, R. E. (2005). Doğu Karadeniz'de 8 Demersal Balık Türünün Boy-Ağırlık İlişkisi*. Türk Sucul Yaşam Dergisi, Ulusal Su Günleri 2005 Sempozyumu, cilt 3(4)*, 19–24.

Froese, R. (2006). Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology*, *22*(4), 241–253.

Fulton, T. W. (1904). The rate of growth of fishes. *Fisheries Board of Scotland Annual Report*, *22*(3), 141–241.

Gayanilo, F. C., Jr., Sparre, P., & Pauly, D. (2005). *FAO ICLARM Stock Assessment Tool II (FiSAT II)*. User's guide and software. Rome: FAO / WorldFish Center. Retrieved from http://www.fao.org/3/y5997e/y5997e00.htm

Karadurmuş, U., Ustaoğlu, D., Öztürk, R. Ç., Terzi, Y., & Aydın, M. (2024). Morphological and genetic characterization of four gobies (Gobiiformes: Gobiidae) commonly found in the Black Sea. *Cahiers de Biologie Marine*, *65*, 227–239. https://doi.org/10.21411/cbm.a.d2347526

Kornis, M. S., Mercado-Silva, N., & Vander Zanden, M. J. (2012). Twenty years of invasion: a review of round goby *Neogobius melanostomus* biology, spread and ecological implications. *Journal of Fish Biology*, *80*(2), 235–285. https://doi.org/10.1111/j.1095-8649.2011.03157.x

Păun, C., Grigoraș, D., Țiganov, G., Galațchi, M., Danilov, C. S., & Nicolae, C. G. (2025). Length-weight relationships and condition factors for the main commercial fish species from the Romanian Black Sea coast. *Scientific Papers. Series D. Animal Science*, *LXVIII*(2), 843–852.

Ricker, W. E. (1973). Linear regressions in fishery research. *Journal of the Fisheries Research Board of Canada*, *30*(3), 409–434.

Ricker, W. E. (1975). Computation and interpretation of biological statistics of fish populations. *Fisheries Research Board of Canada Bulletin*, 191.

Roşca, I., & Mânzu, C. C. (2011). Feeding ecology of knout goby (*Mesogobius batrachocephalus* Pallas, 1814) from the Romanian Black Sea (Agigea–Eforie Nord area). *Aquaculture, Aquarium, Conservation & Legislation – International Journal of the Bioflux Society*, *4*(2), 123–129.

Roşca, I., & Surugiu, V. (2010). Feeding ecology of some benthic fish species from the Romanian Black Sea coast (Agigea-Eforie Nord Area). *Analele Ştiinţifice ale Universităţii "Al. I. Cuza" Iaşi, Seria Biologie Animală*, *56*, 249–256.

Țiganov, G., Anton, E., & Galatchi, M. (2023). Selectivity of cage fishing tools used in the goby fisheries in Romania. *Acta Zoologica Bulgarica*, *75*(1), 85–90.

Vasil'eva, E. D., & Vasil'ev, V. P. (2025). Morphological variability and species structure of tubenose gobies of genus Proterorhinus (Gobiidae) of the Black Sea: Diagnostic characters and distribution patterns. *Journal of Ichthyology*, *65*(3), 263–279. https://doi.org/10.1134/S003294522570002X

Weatherley, A. H., & Gill, H. S. (1987). *The Biology of Fish Growth*. London, UK: Academic Press Publishing House.

Zarev, V., Apostolou, A., Velkov, B., & Vassilev, M. (2013). Bulgarian Black Sea gobies as important object in the commercial fishing. *Bulgarian Journal of Agricultural Science*, *19*(Supplement 2), 233–236.