Mar. Sci. Tech. Bull. (2023) 12(1): 1-11
e–ISSN: 2147–9666
info@masteb.com

dergipark.org.tr/en/pub/masteb
www.masteb.com
DOI: 10.33714/masteb.1178161

Marine Science and Technology Bulletin

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RESEARCH ARTICLE

Population structure, exploitation status, and prospects of brown meagre *Sciaena umbra* Linnaeus, 1758 from the Turkish coast of the Black Sea

Barış Bodur[1] • Mehmet Aydın[1] • Uğur Karadurmuş[2*]

[1] *Ordu University, Fatsa Faculty of Marine Sciences, Department of Fisheries Technology Engineering, Ordu 52400, Türkiye*
[2] *Bandırma Onyedi Eylül University, Maritime Vocational School, Department of Underwater Technology, Balıkesir 10200, Türkiye*

ARTICLE INFO

Article History:
Received: 21.09.2022
Received in revised form: 24.10.2022
Accepted: 16.11.2022
Available online: 17.02.2023

Keywords:
Sciaenidae
Fisheries
Growth
Mortality
Exploitation ratio

ABSTRACT

The brown meagre (*Sciaena umbra* Linnaeus, 1758) population has experienced dramatic population declines, and it was regionally assessed as "Near Threatened" in the Mediterranean. In this study, the current status of brown meagre populations in the Black Sea was evaluated by estimating growth and mortality rates based on age readings from the otolith. All specimens were collected by commercial trammel nets between March 2019 and February 2020 in the Turkish coast of the Black Sea. A total of 324 brown meagre were sampled during the study period, ranging in age from 0 to 26. The peak spawning season of the species was from June to July. The Von Bertalanffy growth parameters of (L_∞ = 54.15, k = 0.14 yr^{-1}, t_0 = -3.11) supports previous studies and suggests that brown meagre is a long-lived and slow-growing species. The exploitation ratio of 0.53 for females and 0.47 for males. Life-history features and mortalities indicate that the brown meagre has relatively high fertility but may be undefended to intense fishing pressure. However, the impact of overfishing, pollution and climate change can have increasingly detrimental effects on the overall population size of this population.

Please cite this paper as follows:

Bodur, B., Aydın, M., & Karadurmuş, U. (2023). Population structure, exploitation status, and prospects of brown meagre *Sciaena umbra* Linnaeus, 1758 from the Turkish coast of the Black Sea. *Marine Science and Technology Bulletin*, *12*(1), 1-11. https://doi.org/10.33714/masteb.1178161

Introduction

The brown meagre (*Sciaena umbra* Linnaeus, 1758) occurs in the Eastern Atlantic, Mediterranean, and the Black Sea (Chao & Trewavas, 1990). It is a demersal species inhabiting coastal areas, mostly on hard substrata such as rocks and rock cavities and among seagrass meadows (Harmelin, 1991). *S. umbra* is a slow-growing and long-lived species which can live for up to 31 years (Morat et al., 2017). Individuals mature at 3–4 years of age and reproduce in summer (Grau et al., 2009). The small-scale

* Corresponding author
E-mail address: ukaradurmus@bandirma.edu.tr (U. Karadurmuş)

artisanal fishery frequently prefers brown meagre, because of its economic value (Engin & Seyhan, 2009). In Türkiye, otoliths are pulverized and used in the treatment of urinary tract infections (Frimodt, 1995), this has not been proven (Ergin et al., 2017). The brown meagre fisheries mostly occurred by trammel nets, hand lines in the Black Sea, and commercial scorpion-fish nets as bycatch (Aydın et al., 2015). Spearfishing is also common in brown meagre on the Black Sea coast. Individuals are extremely susceptible to spearfishing as it is slow-moving and accessible (Grau et al., 2009). The stock abundance of brown meagre in the world experienced a rapid decline in the last decades, and it has become a protected species (Chauvet, 1991). FAO catch statistics the overall trend shows a gradual increase in landings since the early 2000s (FAO, 2019). Chater et al. (2018) reported that this species is slightly over-exploited in the Gulf of Tunis. *S. umbra* has been listed as "Near Threatened" in the IUCN Red List of Threatened Species due to the decreasing population trend in the Mediterranean Sea (Chao, 2020). With the decrease of the brown meagre populations along the Mediterranean Sea, brown meagre is protected with Annexe III (Protected Fauna Species) of the Barcelona and Bern Conventions. In Türkiye, there is only a length prohibition to protect individuals smaller than 35 cm (Directorate General of Fisheries and Aquaculture, 2020). Several studies have been published on the population status of brown meagre from different regions (Chauvet, 1991; Chakroun-Marzouk & Ktari, 2003; Ragonese et al., 2004; Artüz, 2006; La Mesa et al., 2008; Engin & Seyhan, 2009; Chater et al., 2018; Aydın & Bodur, 2021). Despite its economic and ecological importance, studies on brown meagre populations are either sparse or lacking in the world and the Black Sea (Froese & Pauly, 2022). The objective of this work was to reveal the current status of the populations of brown meagre on the Turkish coast of the Black Sea and examine it in terms of multi population parameters. This study provides valuable assumptions about the future of populations by evaluating the growth, mortality rates, and exploitation of brown meagre for female and male individuals together, as opposed to reports from previous studies.

Material and Methods

Study Area, Sampling and Laboratory Routines

This study was conducted on the Turkish coast of the Black Sea (between 41°37'13.2" N–36°07'06.8" E and 40°54'54.0" N–40°09'41.0" E) between March 2019 and February 2020 (Figure 1). Specimens were monthly captured by commercial trammel nets with various mesh sizes (inner panel: 20 – 120 mm; outer panel: 120 – 240 mm) in rocky and hard substrata regions at 0–30 m depth.

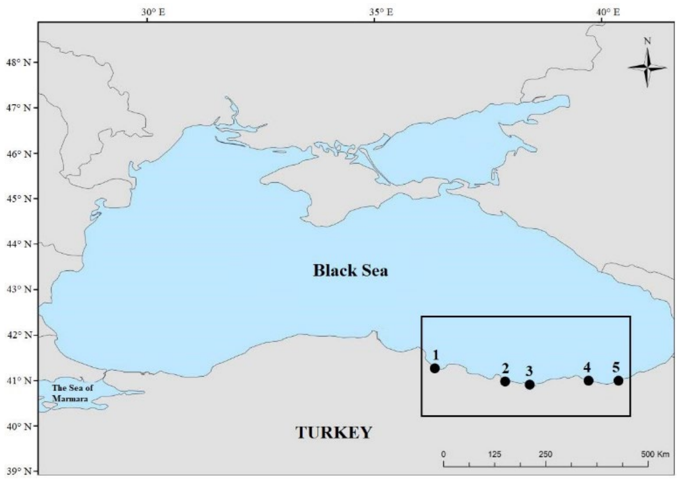

Figure 1. Study area from the Turkish coast of the Black Sea (1: Samsun, 2: Ordu, 3: Giresun, 4: Trabzon, 5: Rize)

Total length (TL) was measured to the nearest 0.1 mm using an ichthyometer, and total weight (W) was taken by an electronic balance of 0.01 g accuracy. Sex determination was made by macroscopic gonadal examination according to the shape and color of gonads (West, 1990; Murua et al., 2003). Age determined was based on otolith readings and confirmed by length frequency analysis. Sagittal otoliths embedded in polyester resin were cut through the 0.375 mm cross-section from the nucleus using a low-speed saw (Buehler Isomet) equipped with a diamond blade. Sectioned otoliths were placed on glass slides and analyzed at 20× magnification with a calibrated ocular microscope using imaging software (Nikon NIS Elements 3.0) (Secor et al., 1992). Age readings were completed by two readers without reference to the size or catch details for each fish. The index of average percentage error (IAPE) (Beamish & Fournier, 1981) was calculated to compare readings. For IAPE values equal to or greater than 10% (13 samples), a third reading was performed. There was no IAPE greater than or equal to 10% after third readings. All otoliths were included in the dataset. The otolith image of the oldest female individual determined for the Black Sea population is given in Figure 2.

Data Analysis

The overall sex ratio (M:F) was calculated as the proportion of males to females, and the Chi-squared test (χ^2) was used to detect the variation from the expected ratio (1:1) (Düzgüneş et al., 1983). The length-weight relationship (LWR) was calculated using the Eq. (1):

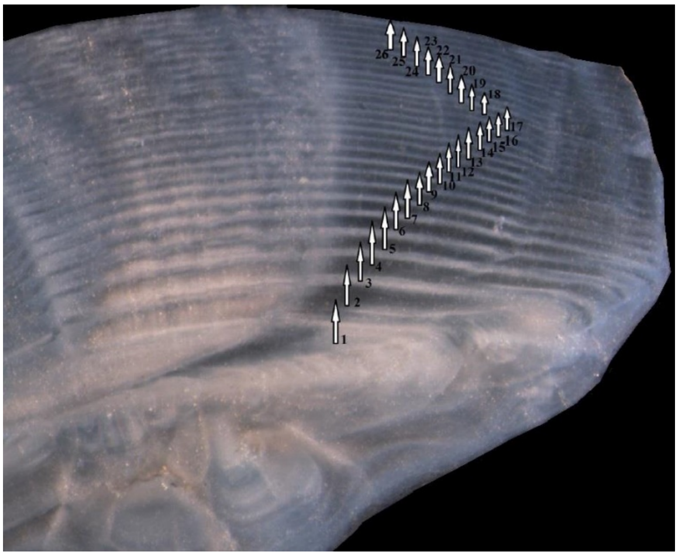

Figure 2. Surface view of the sagittal otoliths of a 26-year-old female *Sciaena umbra* captured in the Fener Island, Fatsa, Ordu (41°03'41.2" N – 37°30'37.2" E).

$$W = a\,L^b \quad (1)$$

where W is the total body weight (g), L is the TL measurement (cm), a is the intercept, and b is the slope (Le Cren, 1951). The b value of sexes was checked by Pauly t-test (Zar, 1999) in order to approve if it was importantly different from the isometric growth (H_0: $b = 3$). Fulton's condition factor (Kn) was estimated equation as per formula given Eq. (2):

$$Kn = \frac{W \times 100}{L^3} \quad (2)$$

where W is the total body weight (g), L is the TL measurement (cm). The von Bertalanffy growth functions (VBGF) were calculated for each sex group by using Eq. (3):

$$L_t = L_\infty\,(1 - e^{-k(t-t_0)}) \quad (3)$$

where L_t is the mean length at age t, L_∞ is asymptotic length (cm), t is age (year), k is the growth coefficient (year^{-1}), and t_0 is the hypothetical age at which the length is zero (year) (Beverton & Holt, 1957; Pauly, 1983). Considering the growth parameters, the Phi-prime growth performance index (φ′) makes it possible to compare the growth of different populations estimated using Eq. (4) (Pauly & Munro, 1984):

$$\varphi' = \log K + 2\log L_\infty \quad (4)$$

The total mortality (Z) was computed using and age-based catch curve analysis (Chapman & Robson, 1960):

$$\log\left(\frac{N_t}{\Delta t}\right) = a + b_t \quad (5)$$

where N is the number of samples of relative age (t), Δt is the time needed to grow from the lower (t_1) to the upper (t_2) limit, and t is the relative age suitable to the midrange of the length class. The absolute value of the curve's slope (b) gives Z. Natural mortality (M) was calculated using the length-growth data by the multiple regression (Pauly, 1980):

$$\log_{10} M = -0.0066 - 0.279\,\log_{10} L_\infty + 0.6543\,\log_{10}(K) + 0.4634\,\log_{10}(T) \quad (6)$$

where M is the natural mortality, L_∞ (TL, cm) is the asymptotic size of the samples and K samples growth coefficient. The value of T is the annual mean temperature (in °C) of the seawater. Fishing mortality (F) was estimated in Eq. (7):

$$F = M - Z \quad (7)$$

Exploitation ratio (E) was calculated, which permits one to (roughly) define if a stock is overfished or not, on the assumption that the ideal value is approximately equal to 0.5 according to Eq. (8):

$$E = \frac{F}{Z} \times 100 \quad (8)$$

The spawning period was estimated by monthly analysis of gonadosomatic index changes:

$$GSI = (W_g \times (W - W_g)^{-1}) \times 100 \quad (9)$$

where W_g is the gonad weight (g), and W is the total weight (g) of fish (Avşar, 2005). The gravimetric process was used for fecundity calculations (Bagenal & Braum, 1978; Murua et al., 2003). This involves subsampling eggs by weighing from the gonad for fecundity estimation. In order to calculate fecundity (F), all oocytes in each ovary sub-sample were counted directly under stereoscopic and calculated according to Bagenal (1978). Egg diameters were measured across the longest axis to the nearest 0.01 μm and calculated by averaging the diameters for each batch (Jakobsen et al., 2009).

The descriptive statistics of the morphometric features were calculated using the statistics software SPSS v26.0. The normality of the variables was checked using the Kolmogorov-Smirnov test, depending on the sample size. Because the data were not normally distributed, statistical analyses by sexes were compared using the non-parametric Mann-Whitney U test. Non-parametric Krusukal-Wallis H test was used to test the difference of GSI and *Kn* values between months. Significance levels for all statistical tests were established at $P = 0.05$ a priori.

Results

Sex Ratio

During the present study, 324 brown meagres were collected, with 181 (55.86%) and 143 (44.14%) individuals of females and males, respectively. The sex ratio (males: females) in the catches was 1:1.27, sex ratio was significantly differed from the expected ratio (χ^2 test = 4.457, $df = 1$, $P = 0.035$).

Length-Weight Distribution

The TL of the samples ranged 11.9 – 58.0 cm (32.2 ± 0.7 cm on mean) and 11.7 – 53.0 cm (28.9 ± 0.8) for females and males, respectively. The TL frequency distribution (Figure 3) differed from the normal distribution in the females (KS-test = 0.111, n = 181, $P < 0.001$) and males (KS-test = 0.136, n = 143, $P < 0.001$). The difference between the TL was significant by sexes (Mann-Whitney U test, $U = 10332.5$, $Z = -3.116$, $N_f = 181$, $N_m = 143$, $P = 0.002$). The W of the females and males was 11.3 – 2485.2 g (595.5 ± 40.4 g) and 16.4 – 1825.0 g (416.7 ± 33.3 g), respectively. The frequency distributions of the W of the females and males differed from normal distributions (KS-test = 0.192, $N_f = 181$, $N_m = 143$, $P < 0.001$). The difference between the W was significant by sexes (Mann-Whitney U test, $U = 10159.0$, $Z = -3.323$, $N_f = 181$, $N_m = 143$, $P = 0.001$).

Length-Weight Relationship and Condition Factor

The LWR equation was estimated $W = 0.007TL^{3.201}$ ($r^2 = 0.982$) for females, $W = 0.007TL^{3.190}$ ($r^2 = 0.986$) for males and $W = 0.007TL^{3.203}$ ($r^2 = 0.984$) for both sexes. The *b* values were significantly higher than 3, meaning that the body shape of female (t–test, $t_{181} = 6.19$, $P < 0.05$), male (t–test, $t_{143} = 5.83$, $P < 0.05$) and both sexes (t–test, $t_{324} = 8.95$, $P < 0.05$) displays a positive allometric form.

The mean *Kn* values were calculated as 1.34 ± 0.01 for females (ranging from 1.21 to 1.56) and 1.27 ± 0.02 for males (ranging from 1.10 to 1.40) (Figure 4). *Kn* values showed a significant difference among sexes (Mann-Whitney U test, U = 8492.0, Z = -3.365, $P < 0.05$). The mean *Kn* were significantly different across months for females (Kruskal-Wallis test, H = 23.240, df = 11, $P < 0.05$) and males (Kruskal-Wallis test, H = 44.297, df = 11, $P < 0.05$).

Spawning Period, Fecundity and Egg Diameters

The monthly mean GSI values ranged from 0.89 (December) to 3.76 (June) for females (with a mean value of 1.92 for the year) and ranged from 0.19 (December) to 3.21 (June) for males (with a mean value of 1.15 for the year). Spawning occurred in one clear peak from June to July (Figure 5). GSI values showed a significant difference among sexes (Mann-Whitney U test, U = 5745.0, Z = -7.071, $P < 0.05$). The mean GSI were significantly different across months for females (Kruskal-Wallis test, H = 23.654, df = 11, $P < 0.05$) and males (Kruskal-Wallis test, H = 33.036, df = 11, $P < 0.05$).

The mean fecundity per female was estimated as 480,274 ± 49,133 egg·ind^{-1} (ranged from 271,694 to 1,091,538 egg·ind^{-1}). The mean fecundity was estimated as 480,275. There were linear correlations between fecundity with TL (F = 18993TL + 261851; n = 20; $r^2 = 0.261$) and W (ED = 456.99W - 104801; n = 20; $r^2 = 0.504$). The mean egg diameter was measured as 719 ± 39 µm, with a range among females from 525 to 1140 µm. The relationship between ED and TL was estimated as ED = 5.78TL + 463.72 (n = 20; $r^2 = 0.016$), while between ED and W was estimated as ED = -0.02W + 750.62 (n = 20; $r^2 = 0.002$).

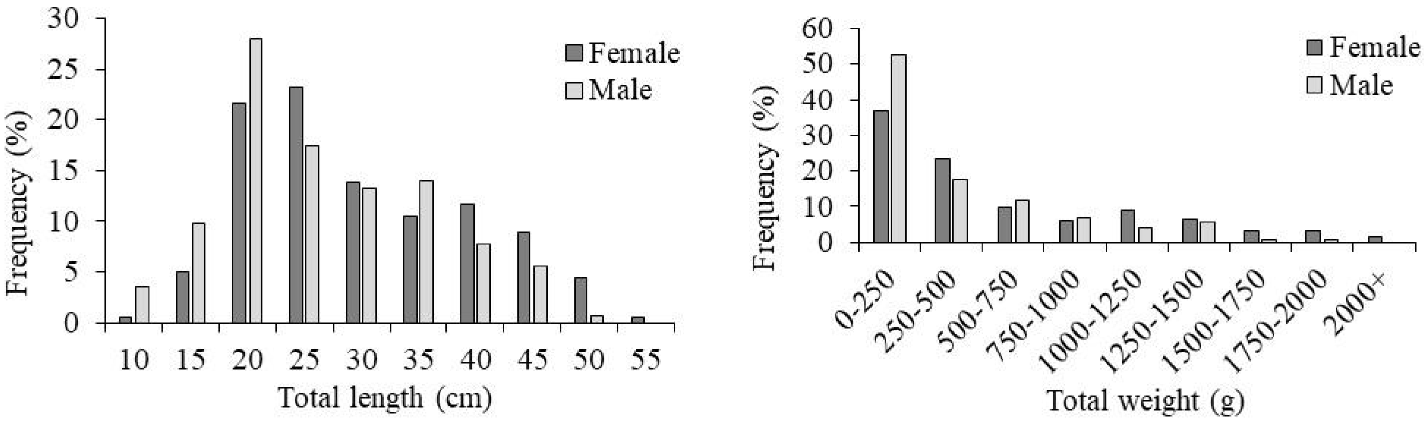

Figure 3. Sex-specific total length (cm) and total weight (g) frequency distribution of *Sciaena umbra* in the Black Sea

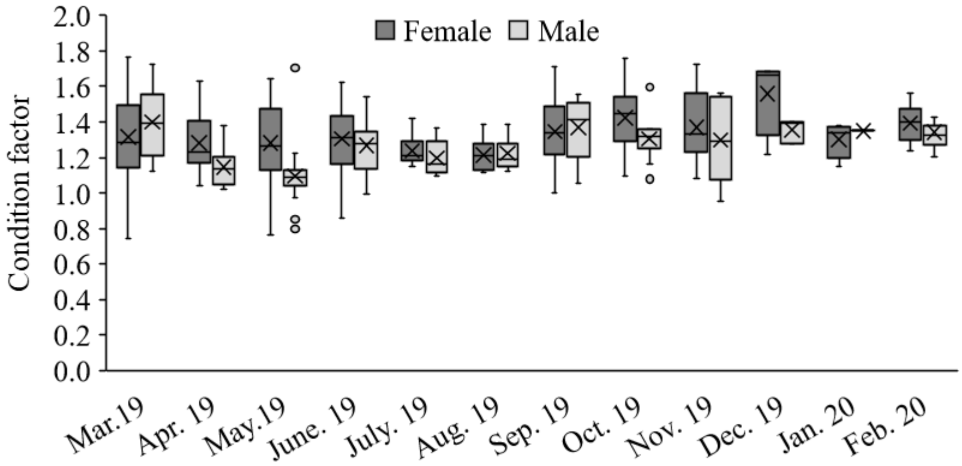

Figure 4. Monthly change of condition factor of *Sciaena umbra* by sexes in the Black Sea (2019-2020)

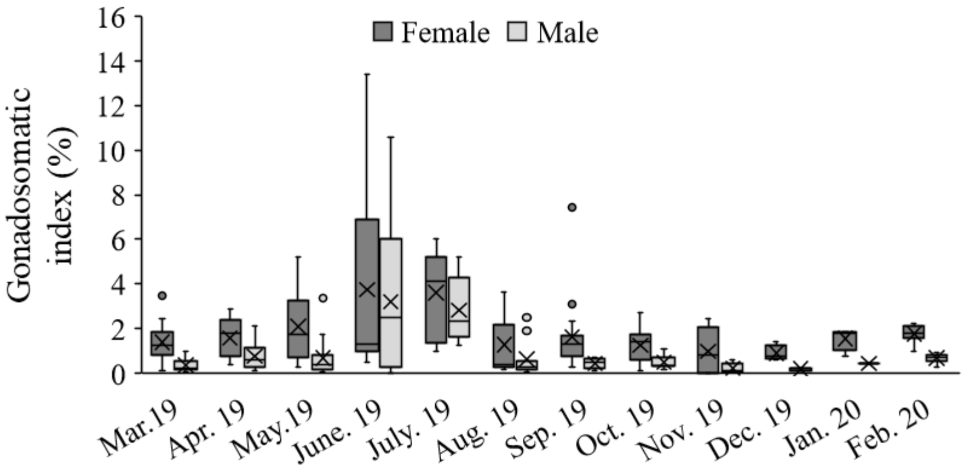

Figure 5. Monthly change of gonadosomatic index of *Sciaena umbra* by sexes in the Black Sea (2019-2020)

Age Composition and Growth Parameters

Among the total sections examined (n = 324), 313 (96.6%) yielded useful age estimates and reading of 13 sections were repeated as they showed disagreement between the two readings. An APE value of less than 10% was obtained in all sections after the third readings.

The proportion of individuals aged five years and younger in the population was 69.06% for females and 71.33% for males (Figure 6). According to the frequency of occurrence, the highest number of individuals was in age-class 2, with 64 females and 35 males. The maximum age of the females and males was 26 and 24 years, respectively. The age-length key of the sampled brown meagre is detailed in Table 1.

The maximum observed lengths for males and females were higher than the calculated value of the asymptotic length of sampled brown meagre. The growth performance of females (φ' = 2.7) was calculated as higher than that of males (φ' = 2.57). The VBGF growth curve of the sampled brown meagre was detailed in Table 2.

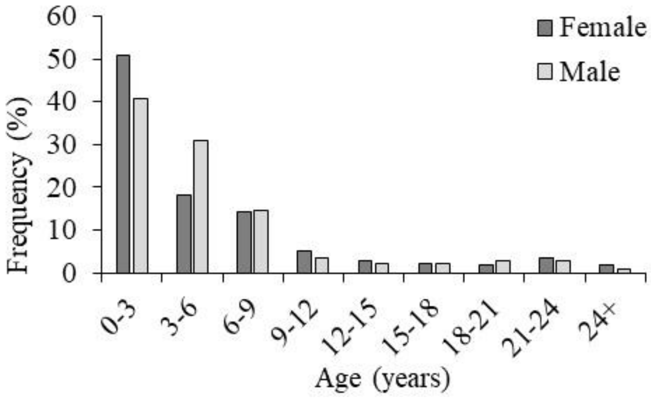

Figure 6. Sex-specific age (years) frequency distribution of *Sciaena umbra* in the Black Sea

Mortality, Exploitation and Survival Rate

The estimates of *Z* from the descending slope of the catch curve were 0.85 for females and 0.67 for males. The values of *M* were calculated to be 0.40 for females and 0.35 for males. The corresponding *F* was estimated as 0.45 for females and 0.32 for males. The *E* of brown meagre was estimated, with 53% for females and 47% for males. The survival rate (*S*) was calculated as 0.51 in females and 0.49 in males.

Table 1. The age-length key of the sampled *Sciaena umbra* in the Black Sea according to size class

Age groups	**Total length, cm**										
	10	***15***	***20***	***25***	***30***	***35***	***40***	***45***	***50***	***55***	***Total***
0	6	3									9
1		18	24								42
2		2	51	43	3						99
3			4	17	16	2					39
4				7	8	2	1				18
5					11	8	1				20
6					5	9	5	1			20
7						11	4				15
8					1	5	6				12
9						2	4				6
10							4	1			5
11							1	2			3
12							1	2			3
13							1	1			2
14							1	2			3
15							1	2			3
16								2			2
17								2			2
18							1	1			2
19							1	1			2
20								3			3
21								2	2		4
22								1	1		2
23								1	3		4
24									2		2
25									1		1
26										1	1
Total	6	23	79	67	44	39	32	24	9	1	324

Table 2. Estimates of von Bertalanffy growth parameters of sampled *Sciaena umbra* in the Black Sea

VBGF parameters	**Female**	**Male**	**Combined**
L_∞ (cm)	52.30	49.72	54.15
W_∞ (g)	2086.59	1725.80	2332.13
k·year^{-1}	0.18	0.15	0.14
t_0 (year)	-1.67	-10.54	-3.11
φ′	2.7	2.57	2.6

Discussion

A female-biased population was detected in the Black Sea region, similar to the ratio found in the Gulf of Tunis (Chakroun-Marzouk & Ktari, 2003) and Balearic coasts (Grau et al., 2009). Male-dominated populations also exist in the north-western Adriatic (La Mesa et al., 2008) and Gulf of Tunis (Chater et al., 2018). Males were dominant during the early sizes, but after a larger 25 cm, the sex ratio changed in favor of females. The fact that females are the majority in the Black Sea population seems promising for the reproductive potential and the continuity of the stocks. The maximum age was determined as 26 years for a female in the Black Sea. Several authors reported a shorter life cycle (up to age 20) on northern Tunisian coasts (Chauvet, 1991), Maltese coasts (Ragonese et al., 2004), and the Sea of Marmara (Artüz, 2006). The most extended lifespan of the brown meagre reported so far was 31 years in the natural populations of the marine reserve of Scandola (Morat et al., 2017) and the Gulf of Tunis (Chater et al., 2018). The *b* values calculated for the Black Sea population were within the expected ranges of 2.5 – 3.5 (Carlander, 1969). Positive allometric growth was observed in fish from the Black Sea (current study), as in different regions (Morey et al., 2003; Karakulak et al., 2006; La Mesa et al., 2008; Engin & Seyhan, 2009; Grau et al., 2009; Bilge et al., 2014; Chater et al., 2018; Aydın & Bengil, 2020; Aydın & Bodur, 2021), indicating that individuals grow faster in weight than in length. High conditions ($Kn > 1$) estimated for brown meagre in the Black Sea may be signs of favourable environmental conditions and good nutrition (Le Cren, 1951; Ujjania et al., 2012).

High t_0 (-3.109) indicated the rapid growth rate of juveniles. During the first three years of their life, females have reached 54% and males 50% of their maximum length. A rapid increase in size attained approximately 50% of their L_{max} was verified during the first three years of life for brown meagre (Chakroun-Marzouk & Ktari, 2003; La Mesa et al., 2008; Chater et al., 2018). The theoretical length of the individuals in the current study (L_∞ = 54.15 cm TL) was not different from values estimated for the northern Tunisian coasts (Chauvet, 1991) and Gulf of Tunis (Chakroun-Marzouk & Ktari, 2003). Artüz (2006) reported a very high value (L_∞ = 69.80 cm TL) from the Sea of Marmara. The determined longer L_∞ in this study compared to specimens in Maltese coasts (Ragonese et al., 2004), northwestern Adriatic (La Mesa et al., 2008), southeastern Black Sea (Engin & Seyhan, 2009) and Gulf of Tunis (Chater et al., 2018) might indicate that Black Sea populations have better environmental conditions for growth. As in previous studies (Table 3), females (k = 0.18 yr^{-1}) were also found to grow faster than males (k = 0.15 yr^{-1}) in the Black Sea. The values of the k confirmed slow attainment of the maximum size, which is rather typical of long-life cycle species. The k value was not noticeably different from values estimated for some Tunisian brown meagre populations (Chauvet, 1991; Chakroun-Marzouk & Ktari, 2003; Chater et al., 2018) which have varied between 0.10 yr^{-1} and 0.22 yr^{-1} among sexes. Significantly higher k values were reported from the Sea of Marmara, Türkiye, which has k values of 0.42 yr^{-1}. These results were slightly lower than the calculated for the Southern Black Sea (Engin & Seyhan, 2009) and Northwestern Adriatic (La Mesa et al., 2008). Differences in growth performance between regions are likely due to environmental conditions (such as temperature and food availability) between sampled areas (Tuck et al., 1997; Campana, 2001), the unequal distribution of size classes (Mouine-Oueslati et al., 2015). The growth performance index of the Black Sea populations (φ' = 2.70) was quite close to previous studies (Chauvet, 1991; Chakroun-Marzouk & Ktari, 2003; Engin & Seyhan, 2009; Chater et al., 2018) which may further clarify the various maximum theoretical length in populations from different regions.

Estimates of *Z* for the brown meagre were low, characteristic of a long-lived and slow-growing species. These estimates are higher than the *M* values reported in the Gulf of Tunis (Chater et al., 2018). The overall annual mortality rate includes recreational fishing and natural sources of mortality. The *Z* for females (Z = 0.85 yr^{-1}) was greater than males (Z = 0.67 yr^{-1}). The higher *M* values in females may be due to their larger size, making them more sensitive to fishing. Fishing mortality results demonstrate that males (F = 0.45 yr^{-1}) are fished at a higher rate than females (F = 0.32 yr^{-1}). The current exploitation rate of the Black Sea population was calculated near the optimum exploitation level (E = 0.5) of fish populations (Patterson, 1992). The brown meagre stock in the Black Sea appears mainly unexploited (E ~ 50%, $F/M < 1$) for females and males.

The peak spawning season of the brown meagre occurred from June to July in the Black Sea. The spawning season was reported similarly from July to August from the Gulf of Tunis (Chakroun-Marzouk & Ktari, 2003) and only in June from the southeastern Black Sea (Engin & Seyhan, 2009). Distinctive spawning aggregations of brown meagre (Harmelin, 1991) can

Table 3. The von Bertalanffy growth parameters obtained from different regions for the *Sciaena umbra*

References	Region	Sex	n	TL (cm)	Age max	TL_∞ (cm)	k (yr^{-1})	t_0 (years)
Chauvet (1991)	Tunisian coasts	Females	–	12.5 – 52.5	21	53.90	0.190	-0.002
		Males	–	12.4 – 44.5	15	46.70	0.224	-0.120
Chakroun-Marzouk & Ktari (2003)	Gulf of Tunis	Females	484	13.4 – 49.6	9	53.70	0.186	-0.828
		Males	394	13.6 – 44.4	9	45.00	0.225	-0.817
Ragonese et al. (2004)	Maltese coasts	Females	51	31.1 – 48.5	26	47.60	0.116	-6.132
		Males	129	30.5 – 43.0	17	42.30	0.145	-5.765
Artüz (2006)	Sea of Marmara	Combined	921	–	21	69.80	0.418	-1.075
La Mesa et al. (2008)	Northwestern Adriatic	Females	118	20.0 – 49.7	16	47.20	0.279	-1.823
		Males	128	16.5 – 48.0	19	44.90	0.268	-2.168
Engin & Seyhan (2009)	Southeastern Black Sea	Combined	329	–	18	51.14	0.270	-0.930
Chater et al. (2018)	Gulf of Tunis	Females	113	19.1 – 49.2	31	50.10	0.105	-5.710
		Males	113	17.6 – 43.3	22	43.83	0.145	-4.880
Current study	Black Sea	Females	181	11.9 – 58.0	26	52.30	0.180	-1.670
		Males	143	11.7 – 53.0	24	49.72	0.150	-10.54
		Combined	324	11.7 – 58.0	26	54.15	0,.137	-3.109

make them particularly vulnerable to spearfishing in caves in the summer. Gonad development of brown meagre was not followed in the current study, but the smallest ovigerous female was 37.0 cm, which was relatively high compared to other populations. Although the first maturity length of the brown meagre was reported to be about 20 cm in the Gulf of Tunis (Chakroun-Marzouk & Ktari, 2003), southeastern Black Sea (Engin & Seyhan, 2009), and 30 cm on Balearic coasts (Grau et al., 2009). Although the L_{max} observed in this study is close to the L_∞, approximately 35% of the females in the population had a reproductive potential (>35 cm). To make possible recovery of this recently over-fished population, a more restrictive arrangement was put forward, where only individuals larger than 35 cm are caught. The brown meagre populations are protected by catch size limitations in Türkiye; currently the legal length size has been increased from 25 cm to 35 cm in the national regulation (Directorate General of Fisheries and Aquaculture, 2020). Such an arrangement would allow most individuals to reach sexual maturity and breed at least once before being caught. This will also protect older and larger individuals with high reproductive capacity. The stock abundance of brown meagre in the world experienced a critical decline, becoming a species to be protected (Chauvet, 1991; Harmelin, 1991; Chater et al., 2018). The brown meagre is not included in any special protection program outside of marine protected areas globally. Unlike the catch size limitation, brown meagre is not protected by any prohibition in Türkiye and is open for commercial and sportive fisheries in the Black Sea. Balanced mortality rates (both natural and fishing) and the presence of older females with high reproductive potential indicate that the welfare level of the population is sustainable for the Black Sea population. This status of stocks does not mean that the brown meagre is resistant to exploitation. As with all marine populations, the brown meagre will not show excessive resistance to overfishing exploitation, so additional management and conservation measures should be taken to minimize the impact of fishing activities on stocks.

Conclusion

Consequently, anthropogenic pressures and human activities on the Black Sea coasts are increasing daily. Fisheries management strategies should consider environmental aspects of the ecosystem in addition to conventional fisheries regulations. It should be noted that further efforts are needed to protect the existence of female adults and juveniles. Small-scale fisheries on the coast of the southern Black Sea must be regulated to minimize their direct impact on brown meagre populations. Trammel nets are fragile in selectivity, and brown meagre creates high bycatch in these nets. Large individuals, including mature females, are attractive for spearfishing and are highly caught. As a long-lived but slow-growing species, we underline those adult females should be excluded from catching for whatever reason. In particular, the survival of all females larger than 35 cm plays a crucial role in the sustainability of brown meagre stocks. It is recommended to create new artificial structures to create shelter, hiding and breeding areas for individuals. Because rocky ecotones are the brown meagre's primary habitat, a special conservation plan is needed to protect these areas. These measures will contribute to the sustainability of brown meagre populations.

Acknowledgements

The data is based on a master thesis results carried out in the Institute of Natural and Applied Sciences, Ordu University, Ordu, Türkiye by Barış Bodur. This study was supported by Scientific Research Coordination Department of Ordu University with a code B-1914.

Compliance With Ethical Standards

Authors' Contributions

BB, MA, & UK: Study design, Writing.
BB & UK: Sampling, Writing.
MA: Supervision, Statistical analysis, Writing
All authors read and approved the final manuscript.

Conflict of Interest

The authors declare that for this article they have no actual, potential, or perceived conflict of interests.

Ethical Approval

For this type of study, formal consent is not required. All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author, [UK], upon reasonable request.

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