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Age, Growth and Mortality Rate of Yellowstripe Barracuda, *Sphyraena Chrysotaenia* Klunzinger 1884 Living in the Northeastern Mediterranean

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Abstract
In this study, biological features of *Sphyraena chrysotaenia* Klunzinger, 1884 determined in Iskenderun Bay (Turkey). A total of 560 individuals were examined by sampling monthly from September 2015 to August 2016. The examined samples were 225 (40.18%) females and 335 (59.82%) males. The total length distribution of *S. chrysotaenia* ranged from 14.0 to 34.5 cm and the weight distribution from 17.0 to 222.0 g. Growth equations for females and males were calculated as respectively $W = 0.0117xL^{2.7922}$ and $W = 0.0097xL^{2.8517}$. The growth of *S. chrysotaenia* was determined as negative allometric. The minimum and maximum ages determined based on otolith readings for females and males ranged from 1 to 6. The von Bertalanffy growth parameters were L_∞= 58.682 cm, K = 0.095 $year^{-1}$, t_0= -2.655 years for females, L_∞= 58.907 cm, K = 0.090 year-^{1}, t_0= -2.686 years for males, and as L_∞= 58.470 cm, K = 0.091 $year^{-1}$, t_0= -2.647 years for both sexes. Fulton condition factor (CF) value was estimated as 0.6105 ± 0.028, for females, as 0.6092 ± 0.024 for males and as 0.6097 ± 0.018 for combined sexes. The total mortality rate (Z) was calculated as 0.503, the natural mortality rate (M) 0.222, and the fishing mortality rate (F) 0.281. Besides, the fishing mortality (F) was estimated higher than the biological reference points (F_{opt} =0.111 and F_{limit} =0.148). The estimated fishing mortality rate and exploitation rate (E = 0.55) obtained results in this study indicate a slightly high fishing pressure on the *S. chrysotaenia* stock in Iskenderun Bay. Besides, these data were discussed with the other geographical areas growth studies of *S. chrysotaenia* in the Mediterranean waters. To the best knowledge of the authors, this study presented the first reference on age, growth and mortality rates for this species; also this study will be useful for fishery biologists and managers.

Keywords Sphyraenidae · Barracuda · Biological features · Eastern Mediterranean · Turkey

Introduction

The yellowstripe barracuda, *Sphyraena chrysotaenia* Klunzinger 1884, is an Indo-Pacific species belonging to the Sphyraenidae family (De Sylvia & Williams, 1986; Froese & Pauly, 2021). *S. chrysotaenia* is distributed in pelagic and demersal zones and usually inhabits large schools in inshore waters often close to surface between 1 and 50 m depths and that it is not found in deeper than 50 m (Golani et al., 2006). This carnivorous species, feed on small fishes (clupeids and anchovy) and also crustaceans. Adult individuals are found in the open waters, while juveniles often occur in very shallow waters (Golani et al., 2002).

The yellowstripe barracuda, *S. chrysotaenia* has a widespread distribution from the Indo Pacific, to the Red Sea, the Persian Gulf, and East Africa throughout the Indian Ocean to Australia, Japan, southern Adriatic Sea, Libya, Malta, and also in the Eastern Mediterranean Sea (Ben-Tuvia, 1986; Froese & Pauly, 2021). Besides, this species was observed in the Aegean Sea, Ionian Sea, Italian coast, and Tunisian waters (Golani, 1998).

The first record of *S. chrysotaenia* as misidentification of *Belone acus* from the Eastern Mediterranean was reported by Spicer (1931) off Palestine in 1931 and then this species was recorded from Libya, Malta waters (Stirn, 1970; Lanfranco, 1993), and north to the southern Adriatic Sea

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(Pallaoro & Dulcic, 2001). *S. chrysotaenia* can easily be distinguished by other Levantine barracudas by the pectoral fin tip is reach the vertical of first dorsal fin origin and, second dorsal, pectoral, caudal fin yellowish (Golani et al., 2002).

S. chrysotaenia was first recorded in İskenderun on the northeastern Mediterranean coast of Turkey in 1957 by Akyuz (Akyuz, 1957). Other successive records of the species from the Turkish coast between Iskenderun Bay and Mersin were presented by Ben-Tuvia (1966) and Gücü et al. (1994). Later this species was successively recorded in the south Aegean Sea (Kusadasi Bay, Aegean Sea, Turkey and Diafani, Karpathos, Greece) (Golani & Ben-Tuvia, 1995).

Although *S. chrysotaenia* is a lessepsian migratory species that entered the Mediterranean from the Red Sea via the Suez Canal, this species is the most common species of barracuda caught by artisanal fisheries in the Eastern Mediterranean. Besides, this species for Turkish Seas has high economic value and, it is common in the Mediterranean coast of Turkey and frequently caught inshore waters using gillnets and by trawlers at depths down to 45 m.

There were many studies on the length and weight of *S. chrysotaenia* in the Mediterranean Sea (Taskavak & Bilecenoglu, 2001; Ceyhan et al., 2009; Erguden et al., 2009; Apostolidis & Stergiou, 2014; Bílge et al., 2014). However, little information is available on the age and growth of *S. chrysotaenia* in the Mediterranean (Allam et al. 2004; Zouari-Ktari et al., 2007; Zouari-Ktari et al., 2009; El Ganainy et al., 2017).

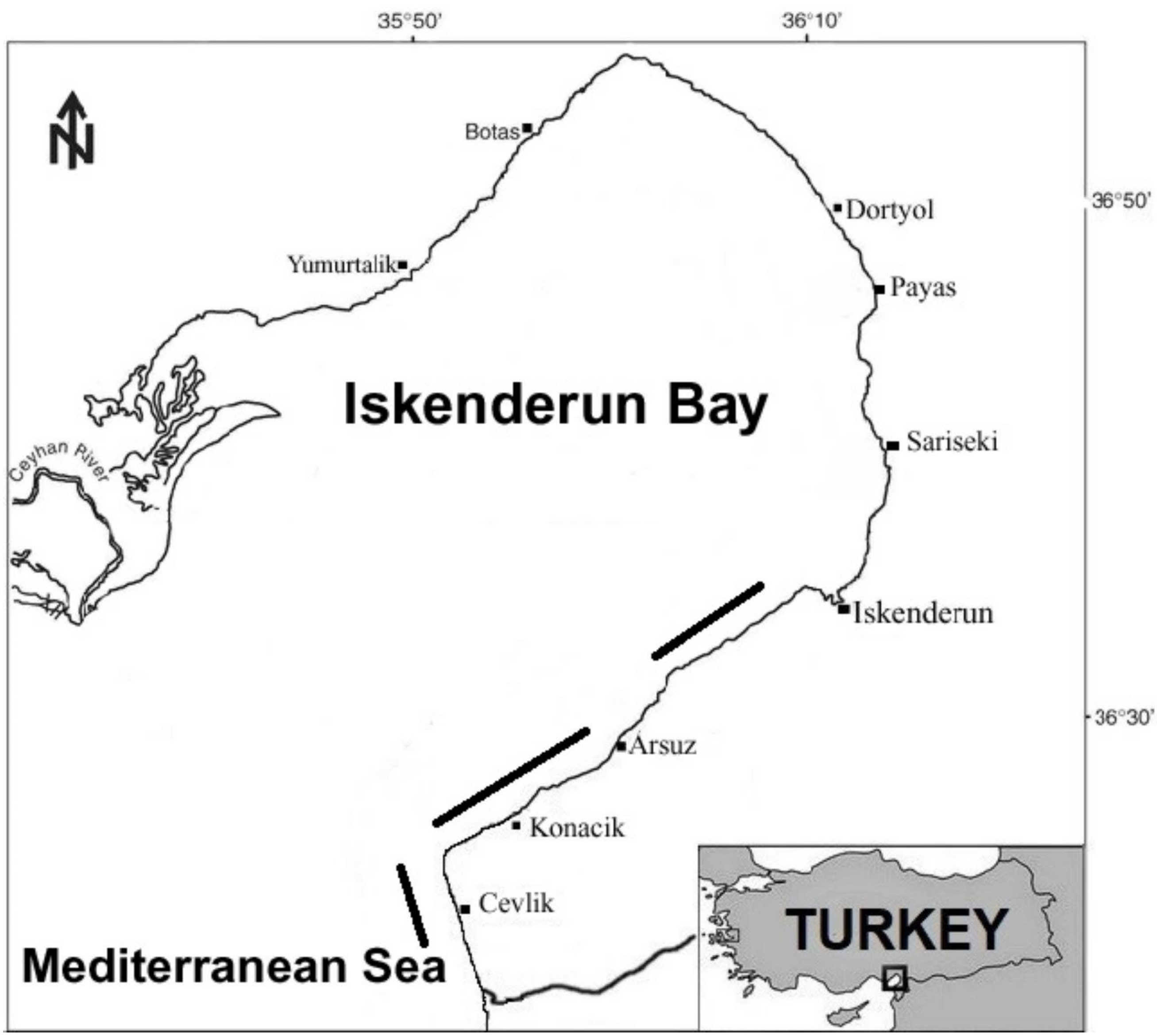

Fig. 1 The study area in the Iskenderun Bay (Northeastern Mediterranean), Turkey

To date, there is no available data regarding comprehensive biology data of *S. chrysotaenia* for the northeastern Mediterranean, Turkey, and so the objectives of this paper are to present study provides the first information on age, growth, and mortality rates of the yellowstripe barracuda, *S. chrysotaenia* from the Iskenderun Bay (NE Mediterranean, Turkey).

Materials and methods

The **y**ellowstripe barracuda, *Sphyraena chrysotaenia* were obtained from the İskenderun Bay between September 2015 and August 2016 using gillnet and commercial trawler (mesh size 44 mm) at depths ranging 12 to 44 m (Fig. 1).

All fish were put in crushed ice and transported to the laboratory immediately for analysis. A total of 560 specimens were measured to the nearest 1 mm (total length, TL) and weighed to the nearest 1 g (total weight, TW). Samples were dissected, and gonads were examined in order to determine their sex.

The length-weight relationship was calculated using the equation $W = aL^b$ (Ricker 1975). This equation can also be expressed in logarithmic form: $log\ TW = log\ a + b\ log\ L$, where W is the total weight, L is the total length, a and b parameters of the equation. The significance of the regression was tested by analysis of variance ANOVA. Students *t*-test was applied to determine the significance of differences (95% level) to verify if it was significantly different from 3 (Zar, 1999).

Age was determined by reading the sagittal otoliths. All otoliths were cleaned in ethanol and then immersed in glycerin for examination. A binocular microscope with reflected light was used for age determination. To minimize misreading, the number of translucent rings outside the nucleus was evaluated by three independent readers. Estimates of the precision of growth annuli (ring) count between readers were determined using the average percentage error (APE) of (Beamish & Fournier, 1981).

The von Bertalanffy growth equation was calculated according to $Lt = L_s\ [1\text{-}e^{-k(t-t_0)}]$ for total length, TL, where L_t is fish length (cm), L_s is the ultimate length an average fish could achieve, t is the fish age (years), t_0 (years) is the hypothetical time at which the fish length is zero, and k is the growth coefficient (years^{-1}) (Sparre & Venema, 1998).

Fulton's coefficient of condition factor (CF) was calculated by $CF = W/L^3 \times 100$, where; L is length (cm) and W is weight (g) (Fulton, 1904; Le Cren, 1951; Sparre & Venema, 1998). The t-test was applied to confirm whether CF varied by gender and months.

The growth performance index (φ′) was used $\varphi' = logK + 2logL_\infty$ as suggested by Pauly and Munro (1984). The growth performance index was estimated to compare growth parameters obtained in this study with those reported by different authors.

The fishing mortality (*F*) was calculated following Pauly (1980): $F = Z - M$. Total mortality rate (Z) was calculated from the length converted catch curve Pauly (1983) using the FISAT program (Gayanilo et al., 1994). The natural mortality (*M*) was estimated from the empirical formula proposed for the Mediterranean fishes by Djabali et al. (1993): $\log M = 0.736–0.114 \log L_\infty + 0.522 \log K + 0.583 \log T$, where the T value was taken as 22.6 °C as this value represented the mean water temperature in the Iskenderun Bay (Gücel and Sakalli, 2018).

The exploitation rate was estimated using this equation $E = F/Z$, where F: fishing mortality, Z: total mortality (Z), (Sparre & Venema, 1998).

The fishery resource status was assessed according to Patterson (1992) by the comparability of the current fishing mortality rate with the optimum or the target (F_{opt}) and limit (F_{limit}) biological reference points which were defined as; F_{opt} = 0.5 M and F_{limit} = 2/3 M. On the other hand, optimum exploitation rate (*E*opt) was determined using Gulland (1971) equation: $E_{opt} = F_{opt}\ (M + F_{opt})^{-1}$.

Results

Fish composition and measurements

A total of 560 yellowstripe barracuda, *S. chrysotaenia* (335 males and 225 females), individuals were collected from the Iskenderun Bay. The population comprised 59.82% of

Table 1 Descriptive statistics and length-weight relationships of *Sphyraena chrysotaenia*

Sex	N	TL_{Mean} (cm) ± SD (TL_{min}-TL_{max})	TW_{Mean} (g) ± SD (TW_{min}-TW_{max})	*a*	*b*	W-L Equations	R^2
Female	225	23.15 ± 3.338 (15.50–33.60)	79.71 ± 35.608 (22.68-206.98)	0.0117	2.710	$W = 0.0117xL^{2.791}$	0.975
Male	335	23.19 ± 4.087 (14.00-34.50)	82.11 ± 43.020 (17.03-222.09)	0.0097	2.851	$W = 0.0097xL^{2.851}$	0.982
Both Sexes	560	23.18 ± 3.812 (14.00-34.50)	81.15 ± 40.232 (17.03-222.09)	0.0102	2.834	$W = 0.0102xL^{2.834}$	0.980

N: Sample number; SD: Standard Deviation; Min: Minimum; Max: Maximum males and 40.18% of females. The sex ratio for male and female individuals (M: F) was 1.00:0.67. The chi-square analysis (χ^2) showed that the sex ratio was significantly different from the expected 1:1 ratio (χ^2, $P<0.05$).

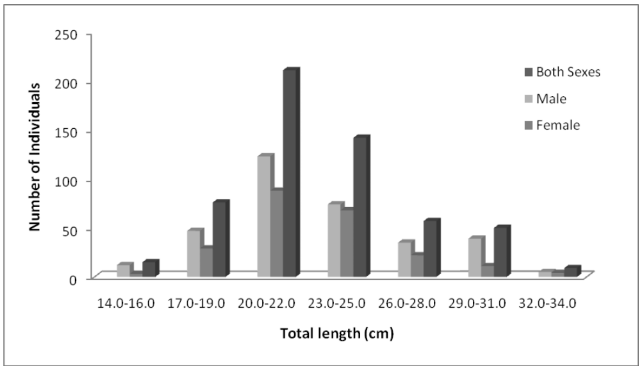

Fig. 2 The length-frequency distributions for male, female, and both sexes of *Sphyraena chrysotaenia* from Northeastern Mediterranean

Total length in males ranged from 14.00 to 34.50 cm with a mean of 23.19 ± 4.087, and total length in females ranged from 15.50 to 33.60 cm with a mean of 23.15 ± 3.338 cm. The mean total weight of males and females values were 82.11 ± 43.020 and 79.71 ± 35.608 g, respectively (Table 1). The maximum total length and the total weight of *S. chrysotaenia* were 34.50 cm and 222.09 g. There was no significant statistical difference between sexes in overall total length and total weight values of male and female individuals (t_{test}, $P>0.05$). The dominant length class in all individuals was 20.0–22.0 cm, TL. Besides, males dominated the all-length class (Fig. 2).

Length-weight relationship

The length-weight relationship of *S. chrysotaenia* was estimated as $logW$=-2.013 + 2.851$logL$ (R^2 = 0.982) for males; $logW$= -1.931 + 2.791$logL$ (R^2 = 0.975) for females and $logW$= -1.991 + 2.834$logL$ (R^2 = 0.980) for both sexes (Table 2). Length and weight relationships for the males,

Table 2 Age-length key for males, females and both sexes of *Sphyraena chrysotaenia* from Iskenderun Bay, Northeastern Mediterranean

	Age Groups						
Length Intervals (cm)	**1**	**2**	**3**	**4**	**5**	**6**	**N**
14.0-14.9	4						4
15.0-15.9	8						8
16.0-16.9	3						3
17.0-17.9	3						3
18.0-18.9	1	19					20
19.0-19.9		53					53
20.0-20.9		97	1				98
21.0-21.9		14	36				50
22.0-22.9		4	59				63
23.0-23.9			55	4			59
24.0-24.9		1	11	37			49
25.0-25.9			9	25			34
26.0-26.9			3	13	3		19
27.0-27.9				4	11		15
28.0-28.9				2	21		23
29.0-29.9				4	11	2	17
30.0-30.9					2	14	16
31.0-31.9						17	17
32.0-32.9					1	4	5
33.0-33.9						3	3
34.0-34.9						1	1
Total	19	188	174	89	49	41	560
Females (N)	4	71	94	33	9	14	225
Males (N)	15	117	80	56	40	27	335
% (Age groups)	3.393	33.571	31.071	15.893	8.750	7.321	100
Females (%N)	1.778	31.556	41.778	14.667	4.000	6.222	100
Males (%N)	4.478	34.925	23.881	16.716	11.940	8.060	100
Mean,TL ± SD	15.80 ± 1.26	20.02 ± 0.85	22.88 ± 1.19	25.35 ± 1.43	28.44 ± 1.08	31.32 ± 1.08	23.18 ± 3.81
Mean,WL ± SD	23.22 ± 4.70	52.13 ± 7.84	72.21 ± 11.03	95.58 ± 17.60	135.54 ± 17.06	182.63 ± 15.18	81.15 ± 40.23
M:F	1:0.267	1:0.607	1:1.175	1:0.589	1:0.225	1:0.519	1:0.671

N = Sample size; F = female; M = male; ±SD = Standard deviation the females, and both sexes were shown in Fig. 3. The coefficient of determination (R^2) was found to be > 0.97, a highly significant value of the result. The regression analysis has shown that fish length had a highly significant correlation with weight ($P < 0.001$).

The exponent of the *b* parameter indicated negative allometry. The *b* values showed no significant difference for males, females, and both sexes (P > 0.05). The comparison of length-weight parameters calculated in this study as well as in previous studies is reported in Table 3.

Age and growth estimation

The age structures estimated by sagittal otoliths of *S. chrysotaenia* ranged from 1 to 6 years for males and females. The year class 2 (33.57%) was dominant, followed by year classes 3 (31.71%), 4 (15.89%), 5(8.7%5) and 6 (7.32%). The total length frequency analysis of *S. chrysotaenia* from the Northeastern Mediterranean Sea is given in Table 2.

The mean average percentage error (APE) was found as 7.1% by three independent readers for *S. chrysotaenia*. Three readers have estimated the same age in 526 of 560 samples. The agreement between three readers on all age assessments was 94%. The difference between readers in the accuracy of age assessment was found insignificant

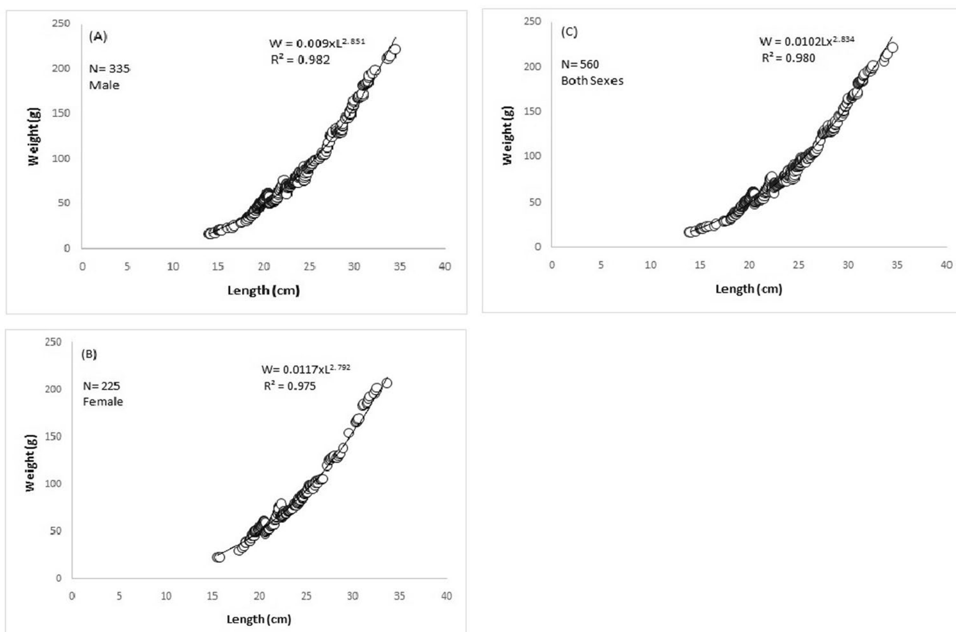

Fig. 3 Length–weight relations for male (A), female (B), and both sexes (C) of *Sphyraena chrysotaenia* from the Northeastern Mediterranean, Turkey

Table 3 Comparisons of *Sphyraena chrysotaenia* length-weight relationship parameters

Area	N	Sex	TL_{min}-TL_{max}	Length Type	Sampling Method	*a*	*b*	R^2	Author(s)
Eastern Mediterranean, Turkey	54	Mixed	12.6–13.1	TL	Bottom Trawler	0.01240	2.632	0.958	Taskavak & Bilecenoglu (2001)
Gulf of Gabes, Tunisia	955	Mixed	12.7–28.3	TL	Bottom-Pelagic Trawlers	0.00048	2.916	0.922	Zouari-Ktari et al. (2007)
Central Mediterranean, Tunisia	380	Female	17.7–28.3	TL	Bottom-Pelagic Trawlers	0.01020	2.819	0.903	Zouari-Ktari et al. (2009)
	412	Male	16.2–24.9	TL		0.00810	2.831	0.955	
Gökova Bay, SE Aegean Sea, Turkey	57	Mixed	19.2–25.0	FL	Trammel net and Longline	0.00620	3.038	0.936	Ceyhan et al. (2009)
NE Mediterranean, Turkey	67	Mixed	27.0-32.2	TL	Bottom Trawler	0.00110	3.413	0.895	Erguden et al. (2009)
Southern Aegean Sea, Turkey	35	Mixed	18.0–24.0	TL	Bottom Trawler	0.00240	3.241	0.966	Bílge et al., (2014)
Gulf of Suez, Egypt	712	Mixed	13.2–28.4	TL	Bottom Trawler	0.01200	2.730	0.915	El Ganainy et al. (2017)
Northeastern Mediterranean, Iskenderun Bay,Turkey	225	Female	15.5–33.6	TL	Gill net and	0.01170	2.791	0.975	This study
	335	Male	14.0-34.5	TL	Bottom Trawler	0.00970	2.851	0.982	

when repeated annuli counts were compared (paired t-test, P > 0.05).

The size of *S. chrysotaenia* to age data was fitted for each sex (male and female) by using von Bertalanffy growth function (VBGF) in order to estimate the growth pattern. The length of individuals assigned to each sex age group of the von Bertalanffy growth parameters was presented in Fig. 4. The von Bertalanffy growth function (VBGF) showed that the male and female fish had a similar growth rate (k = 0.09 y^{-1}). The von Bertalanffy growth parameters were calculated as L_∞= 58.47 cm, k = 0.091 $year^{-1}$, t_0 = -2.647 years for males; L_∞= 58.90 cm, k = 0.090 $year^{-1}$, t_0 = -2.686 years for females; and L_∞= 58.68 cm, k = 0.095 $year^{-1}$, t_0 = -2.655 years for both sexes. The growth performance index (φ′) was found to be 2.492 for males, 2.494 for females, and 2.514 for both sexes (Table 4). The comparisons of von Bertalanffy growth constants for different areas of *S. chrysotaenia* are given in Table 4.

Condition factor

In the study, the condition factor (CF) value was estimated as 0.6105 ± 0.028, for females, 0.6092 ± 0.024 for males, and 0.6097 ± 0.018 for both sexes. Condition factor values showed no significant variations (P > 0.05) of *S. chrysotaenia* between the sexes. Monthly condition factor values for females and males were presented in Fig. 5. The highest value of condition factor was shown in October 2015 for females and in March 2016 for males. The lowest value of condition factor was in May 2016 for females and males (Fig. 5). The monthly variations of the condition factor were not significantly different during all months ($p > 0.05$).

Mortality rates

The total mortality rate (Z) for both sexes calculated was as 0.503 $year^{-1}$. The natural mortality rate (M) computed was 0.222 $year^{-1,}$ and the fishing mortality (F) rate was 0.281 $year^{-1}$. The exploitation ratio was estimated as $E = 0.558$ and the biological reference points were calculated as; the optimum fishing mortality, F_{opt} = 0.111; the fishing mortality limit, F_{limit} = 0.148, and also optimum exploitation rate was estimated as E_{opt}= 0.333.

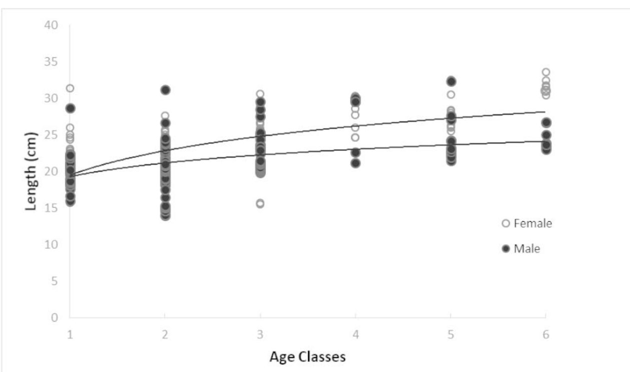

Fig. 4 von Bertalanffy growth curves for male and female of *Sphyraena chrysotaenia* by length at age data

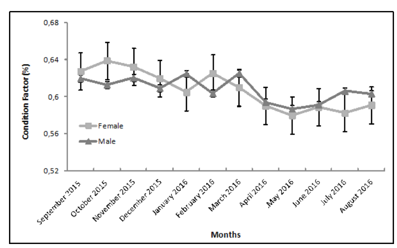

Fig. 5 Monthly average condition factor values of *Sphyraena chrysotaenia* for females and males

Table 4 Growth performance comparisons of *Sphyraena chrysotaenia* from different sampling area

Study	Sex	L_∞	*k*	t_0	Ø'	Area
Kulbicki et al. (1993)	Mixed	26.50	-	-	-	New Caledonia
Allam et al. (2004)	Mixed	27.10	0.390	-1.41	2.460	Egyptian Mediterranean waters, Egypt
Zouari-Ktari et al. (2007)	Female	28.51	0.308	-1.982	-	Gulf of Gabes (Eastern Mediterranean), Tunisia
	Male	25.88	0.401	-1.406	-	
	Both Sexes	28.32	0.319	-1.716	-	
Zouari-Ktari et al. (2009)	Female	28.55	0.311	-1.66	2.404	Central Mediterranean, Tunisia
	Male	26.41	0.366	-1.54	2.407	
Apostolidis & Stergiou (2014)	Mixed	25.00	0.585	-1.13	2.560	Mediterranean waters
El Ganainy et al. (2017)	Mixed	29.37	0.480	-1.02	2.617	Gulf of Suez, Egypt
This study	Female	58.90	0.090	-2.686	2.494	Northeastern Mediterranean, Iskenderun Bay, Turkey
	Male	58.47	0.091	-2.647	2.492	
	Both Sexes	58.68	0.095	-2.655	2.514	

Discussion

Fish composition and measurements

In this study, carried out in Iskenderun Bay (Northeastern Mediterranean, Turkey), the sex ratio of males to females was 1.00:0.67 (335:225) for *S. chrysotaenia*. Besides, it was also observed that males were more dominant in the population than females. Zouari-Kitari et al. (2019) similar reported to the male-dominant population of *S. chrysotaenia* from the central Mediterranean (Gulf of Gabes), Tunisian with a male to female ratio of 1.00:0.84. This small difference in sex ratio could be explained by the seasonal variations in populations, the age of sexual maturity, feeding, and also spawning grounds.

The total length and weight of both sexes ranged from 14.0 to 34.50 cm and from 17.03 to 222.09 g, respectively (Table 1). The size ranges (TL_{min}: 14.0 cm and TL_{max}: 34.50 cm) of *S. chrysotaenia* in the present study are close to those in the Mediterranean coast of Tunisia (Zouari-Ktari et al., 2007; Zouari-Ktari et al., 2009), Egypt (El Ganainy et al., 2017) and Turkey (Ceyhan et al. 2009; Bílge et al., 2014). On the other hand, the size range of *S. sphyraena* in the present study is not in accordance with those recorded in the Mediterranean coast of Turkey (Taskavak & Bilecenoglu, 2001). A detailed comparisons to other populations in the Eastern Mediterranean Sea according to length intervals was given in Table 3. However, our present study was first reported the larger specimen 34.50 cm in total length in the Mediterranean. These differences in overall total length can be explained by different sampling equipment, geographical areas, and depths.

Length-weight relationship

The age classes ranged from 1 to 6 years for males and females. The 2 age class was dominant entire the population (Fig. 4). The maximum length at age was determined as 34.5 cm at 6 age for individuals. The comparable maximum ages in previous studies include age 5+ (28.3 cm) by Zouari-Ktari et al. (2007) and age 5 (28.5 cm) by El Ganainy et al. (2017). Similarly, Wadie & Riskallah (2001) reported age 6 groups of *S. chrysotaenia* in the coast of the southeastern part of the Mediterranean Sea using size-frequency distribution.

The value of the b, showing the nature of growth in fish which varies between 2 and 4 (Tesch, 1971). The b value in fish may vary according to age and sex. In this study, the b (2.834) values were generally in agreement with results of *S. chrysotaenia* from other geographical areas (Taskavak & Bilecenoglu, 2001; Kulbicki et al., 1993; Zouari-Ktari et al., 2009; El Ganainy et al., 2017). However, Ceyhan et al. (2009), Erguden et al. (2009), and Bílge et al., (2014) reported different b values (positive allometry) than are presented in this paper for *S. chrysotaenia* from the Southern Aegean Sea and Eastern Mediterranean Sea, Turkey. These differences in the b value may be related to the combination of one or more factors such as sampling area, habitat, season, maturity, sex, and preservation techniques (Bagenal & Tesch 1978).

Age and growth estimation

The von Bertalanffy growth parameters derived in the present study are generally different from previous studies (Table 4). In our computations, the asymptotic length of *S. chrysotaenia* was L_∞= 58.90 cm for females and L_∞= 58.47 cm for males. Kulbicki et al. (1993) estimated L_∞= 26.50 cm for New Caledonia, while according to Allam et al. (2004), the von Bertalanffy growth parameters for the Egyptian Mediterranean waters (Egypt) were L_∞= 27.10 cm and k = 0.390 year^{-1}. Besides, similar growth for *S. chrysotaenia* from the Gulf of Gabes (Eastern Mediterranean) was L_∞= 28.3 cm and k = 0.319 year^{-1}. Apostolidis & Stergiou (2014) and El Ganainy et al. (2017) reported growth parameters for *S. chrysotaenia* from Mediterranean waters and Gulf of Suez (Egypt) as L_∞= 25.0 cm and k = 0.585 year^{-1} and L_∞= 29.3 cm and k = 0.480 year^{-1} respectively.

Our estimates of the growth parameters from the Iskenderun Bay (northeastern Mediterranean) are higher than those of the others, and these differences with previous studies can be explained partly by the maximum recorded length values for *S. chrysotaenia* individuals in this study. Wotton (1990) stated that fish populations of the same species from different geographical areas may exhibit highly variable, individual growth rates. On the other hand, some differences between growth characteristics may probably be from the quality of food and related to the water temperature (Santic et al., 2002).

The growth performance index (φ′) takes into account the correlation between L_∞ and *k*. The growth performance index for the *S. chrysotaenia* in Iskenderun Bay was 2.514 for both sexes. The overview of growth parameters and growth performance index obtained from previous studies for *S. chrysotaenia* are given in Table 4. This obtained value (φ′) is quite similar to that estimated values for the same species from the Gulf of Suez (Egypt), Egyptian and Tunisian Mediterranean waters (Allam et al., 2004; Zouari-Ktari et al., 2009; El Ganainy et al., 2017) and also Eastern Mediterranean (Apostolidis & Stergiou, 2014). These results are indicating that the environmental conditions are well suitable for the growth of *S. chrysotaenia* in the Mediterranean waters.

Condition factors

Condition factor values were also calculated, where the lowest and highest estimations were found to be 0.5296 and 0.7274, respectively, with a mean value of 0.6105 ± 0.028 for females and 0.5180 and 0.7326, respectively, with a mean value of 0.6092 ± 0.024 for males. Zouari-Ktari et al. (2009) reported the condition of *S. chrysotaenia* from the central Mediterranean waters for females (0.9866 – 0.9670) and males (1.0173–0.9372). If the condition factor is less than 1.0, this value indicates slow growth, possibly due to stress, overcrowding, diseases, low productivity. According to Le Cren (1951) and Ricker (1975) condition factor of fish populations may reveal variations with gonad development, feeding activity, and seasonal changes in growth. The obtained results showed that the condition factor (< 1) of *S. chrysotaenia* in Iskenderun Bay was indicated slow growth.

Mortality rates

In this study, the total mortality rate (Z) of *S. chrysotaenia* individuals estimated from the catch curve was 0.50 $year^{-1}$. The fishing mortality rate (F) was 0.28 $year^{-1}$ and the natural mortality rate (M) was 0.22 $year^{-1}$ for all *S. chrysotaenia* individuals. Allam et al. (2005) are found fairly higher the total mortality of *S. chrysotaenia* according to the Egyptian Mediterranean coast (Z = 1.05 $year^{-1}$). However, the natural mortality rates for *S. chrysotaenia* (M = 0.39), for *S. flavicauda* (M = 0.32), and *S. sphyraena* (M = 0.20) from the Egyptian Mediterranean coast were reported similar to our study by Allam et al. (2005). Besides differently, the mean instantaneous natural mortality of the 4 different methods (Taylor's, Pauly's, Ralston's, and King's) of *S. chrysotaenia* from the Gulf of Gabes (South Tunisian coast) was stated as 0.652 by Zouari-Ktari et al. (2007).

Allam et al. (2005) reported of the fishing mortality rates (F) for *S. chrysotaenia* (F = 0.65), *S. flavicauda* (F = 0.49) and *S. sphyraena* (F = 0.58). The fishing mortality rate (F = 0.28) of *S. chrysotaenia* in the present study is lower than the values obtained (F = 0.65) in the Egyptian Mediterranean coast. According to these reported values, the total mortality (Z), the fishing mortality rate (F), and the natural mortality rate (M) in this study were found comparatively lower than in previous studies. These differences may be explained by fishing effort, biological features, behavior characteristics as well as ecological factors in the different geographical regions.

Pauly (1980) claimed that natural mortality for marine species of 175 fish stocks showed overall modal mortality of M = 0.2–0.3 $year^{-1}$. According to this value, the natural mortality rate of *S. chrysotaenia* gives similar results to the Pauly (1983). Therefore, the natural mortality rate seems to be optimum for *S. chrysotaenia*. On the other hand, Sparre & Venema (1998) also indicated values of natural mortality coefficients for the same species may be different in distinct areas, depending on the density of predators and competitors whose abundance is other influenced by fishing activities.

Gulland (1971) declared that the exploitation ratio should not be more than 0.5 as optimum exploitation. Gulland (1983) also suggested that in an optimally exploited stock the fishing mortality rate (F) is equal to the natural mortality rate (M) or the rate of exploitation (E) is equal to 0.5.

In the present study, the exploitation ratio was estimated as E = 0.55. Allam et al. (2005) reported the exploitation ratio to a higher value for *S. chrysotaenia* (E = 0.62) in the Egyptian Mediterranean waters. Although the exploitation rate (E = 0.55) was close to Gulland (1983). This value indicated that fishing pressure on *S. chrysotaenia* in Iskenderun Bay is slightly high. However, the fishing mortality estimated was lower than in the Egyptian Mediterranean waters. These differences probably are appeared to be area-specific and may be related to the density of fishing pressure for the Northeastern Mediterranean (Iskenderun Bay).

Estimating parameter of the fishing mortality rate (F = 0.28) was higher than the biological reference points derived from the equation of Patterson (1992) as follows: (F_{opt} = 0.11 and F_{limit} = 0.14); additionally the exploitation rate (0.55) was found to be higher than the optimum exploitation rate (E_{opt} = 0.33). Thus, *S. chrysotaenia* in Iskenderun Bay appears to be over-exploited as the fishing mortality (F) is higher than the defined values of reference points F_{opt} and F_{limit}. All these results indicate that the *S. chrysotaenia* stock in the Iskenderun Bay is in a situation of overexploitation and also the current exploitation rate should be reduced to below the level of E = 0.50 for the fisheries management.

Lessepsian species are highly influential on Northeast Mediterranean biodiversity and fisheries. Determining the biological features of the lessepsian migrant fish species such as *S. chrysotaenia* has vital for reflecting the status of established populations and fisheries in the Mediterranean. Although its presence in the region since it has been reported, there has been little or no information about the age growth and mortality parameters of this lessepsian migrant in Iskenderun Bay.

To the best knowledge of the authors, this study presented the first reference on age, growth, and mortality rates for this species; also this study will be very useful for fisheries biologists and managers to know the population structure of this species.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval There is no ethical issue concerning this article.

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