İSTANBUL UNIVERSITY PRESS

EISSN 2602-473X

AQUATIC SCIENCES AND ENGINEERING

Aquat Sci Eng 2018; 33(2): 39-49 • DOI: 10.18864/ASE201807

Original Article

Age, Growth, and Mortality of Exploited Stocks: Anchovy, Sprat, Mediterranean Horse Mackerel, Whiting, and Red Mullet in the Southeastern Black Sea

Nazlı Kasapoğlu

Cite this article as: Kasapoğlu, N. (2018). Age, Growth, and Mortality of Exploited Stocks: Anchovy, Sprat, Mediterranean Horse Mackerel, Whiting, and Red Mullet in the Southeastern Black Sea. Aquatic Sciences and Engineering, 33(2): 39-49.

ABSTRACT

This study aims to calculate the age, growth, and mortality rate of commercially important fish species, namely *Engraulis encrasicolus, Trachurus mediterraneus, Sprattus sprattus, Merlangius merlangus,* and *Mullus barbatus*, in the southeastern Black Sea between 2008 and 2011. These species are commercially important for Turkish and other riparian country fisheries. The samplings were carried out using bottom trawls, purse seines and various gillnets. Length-weight, age-length, the Von Bertalanffy equation, total mortality rate (Z), natural mortality rate (M), fishing mortality rate (F), and exploitation rate (E) were estimated for each species to use in further population analyses and stock assessments research. Additionally, the results of this study were evaluated considering the "Task Group 3 Report-Commercially Exploited Fish and Shellfish" in the Marine Strategy Framework Directive (MSFD) published by the European Commission (2008/56/EC).

Keywords: *E. encrasicolus, T. mediterraneus, S. sprattus, M. merlangus, M. barbatus*, Marine Strategy Framework Directive

INTRODUCTION

Engraulis encrasicolus, Trachurus mediterraneus, Sprattus sprattus, Merlangius merlangus and Mullus barbatus are commercially important fish species in Turkish fisheries. Production of these species in the Black Sea was reported as 176961 tons in total, which represented 34% of Turkish fisheries production (Turkish Statistical Institute (TSI), 2017). Therefore, the Black Sea is an important sea in Turkish fisheries.

The European anchovy, *E. encrasicolus* (Linneaeus, 1758) is a short lived clupeid species distributing along the eastern Atlantic, Scandinavia, West Africa, the Mediterranean, Black and Azov Seas (Whitehead, 1985). The European anchovy mostly spawns during the summer period in the continental shelf with low salinity and high primary production. The migration route of this species is observed throughout the Romanian and Bulgarian coasts, whereas the wintering schools are seen in the Turkish and Georgia coastlines between October and March because these schools migrate towards the north in April and then the coasts of the Black Sea (Ivanov and Beverton, 1985; Karacam and Duzgunes, 1990; Gucu et al., 2016; Gucu et al., 2017). The European anchovy is the most abundant and exploited pelagic fish species and mainly caught by purse seine nets in the Black Sea. It has high trophic level for energy flow in the Black Sea (Daskalov et al., 2007). This species represents the main fishing resource for all the Black Sea countries, particularly for Turkey. There was a dramatic decrease in *E. encrasicolus* production in 1989 and 1990. This reduction was also reported by the other Black Sea countries (Kideys, 1994). The reason for this reduction is overfishing, eutrophication and mainly the effect of an invasive species (*Mnemiopsis leidyi)* (Chashchin, 1996; Gucu, 2002). *E. encrasicolus* is also an important food source

Central Fisheries Research Institute, Trabzon, Turkey

Submitted: 22.08.2017

Accepted: 28.02.2018

Available Online Date: 14.03.2018

Correspondence: Nazlı Kasapoğlu
E-mail: nazliktu@gmail.com

for the other economical fish species living in the Black Sea ecosystem and aquaculture species such as trout; therefore, a significant part of *E. encrasicolus* catch goes to fish meal and oil factories (Samsun et al., 2004). Total catch of European anchovy was 102595 tons for Turkey in 2016 (TSI, 2017) (Figure 1).

The whiting, *M. merlangus* (Nordman, 1840), is a demersal fish and distributes in the northeast Atlantic, Barents Sea, Iceland to Portugal, Black Sea, Aegean Sea, Adriatic Sea, and is rarely found in the western Mediterranean Sea (Froese and Pauly, 2012). The whiting spawns throughout the year in the Black Sea. The whiting does not have a long migration route. It moves depths in the spring (15-30 m) and in autumn (80-120 m) (Shulman, 1974). The whiting is one of the most important demersal species as red mullet in the Black Sea and is mainly caught by bottom trawl and gillnets. Overall catch statistics of the whiting were 11540 tons for Turkey in 2016 (Figure 1) (TSI, 2017). This species feeds mainly on sprat and European anchovy especially along the Anatolian coast of Turkey, and the Caucasian coast. In addition, the whiting stocks must be protected against overfishing because this species is a food source for many predator fish species such as turbot and spiny dog fish (Georgieva and Konsulov, 1993; Maximov and Staicu, 2007; Maximov et al., 2011).

The Mediterranean horse mackerel, *T. mediterraneus* (Steindachner, 1868) from *Carangidae* family is also an economically important species caught by mid-water trawl, gillnet and purse seine. This family is also made up of two other mackerel species, *T. trachurus* (Atlantic horse mackerel) and *T. picturatus* (Blue jack mackerel) (Mater et al., 2002). The Mediterranean horse mackerel is a schooling species. Troughout the high temperate months of the year, *T. mediterraneus* common on the Black Sea, where it generally feeds and breeds (Yankova et al., 2009). The Mediterranean horse mackerel migrates to the north for reproduction and feeding during the spring. In the summer, it distributes in the shelf waters above the thermocline. It migrates towards the wintering grounds along the Anatolian and Caucasian coasts during the autumn (Ivanov and Beverton, 1985). A dramatic decrease occurred in the stocks of this species like the other commercially and non-commercially species mainly because of the *Mnemiopsis* outbreak in 1990. The stocks recovered slightly in the following years and the total production of this species was recorded as 11148 tons for Turkey (Figure 1) (TSI, 2017).

The sprat, *S. sprattus* (Linneus, 1758) is a small pelagic fish distributing in the Atlantic Ocean, Mediterranean, Adriatic and the Black Sea. There are three different species of sprat: *S. sprattus*, *S. balticus* and *S. phalericus* (Whitehead, 1985). *Sprattus sprattus* is a batch spawning species (Torstensen, 1992). Total production of sprat reached up 50224 tons for Turkey (TSI, 2017) (Figure 1) and it was caught by mid-water trawl and purse seine net. This species is an important source for fish meal and oil factories in the Black Sea region because it's not used for human consumption in Turkey.

The red mullet, *M. barbatus* (Linnaeus, 1758), is a demersal species living mainly on sandy and muddy bottoms of the coast and distribution along the Atlantic, Mediterranean, Black and Azov Seas (Hureau, 1986). This species is a benthic carnivore and feeds on small invertebrates mainly on Crustacea, Polychaeta, Mollusca, Echinodermata and small fishes (Celik and Torcu, 2000). The red mullet only migrates locally. The other migrations of red mullet take place in spring from the Kerch Strait to the Sea of Azov. In autumn, it returns to its wintering grounds along the Crimean and northern Caucasian coast. This species is one of the main target species like whiting in the Black Sea fishery along with the whiting and it is also caught by bottom trawl and gillnet. The annual production of red mullet was reported as 1453 tons for Turkey (Figure 1) (TSI, 2017).

There are several studies on the population parameters (Chashchin, 1996; Sahin, 1999; Kasapoglu et al., 2009; Aksu et al., 2011; Erdogan Saglam and Saglam, 2012; Yankova, 2013), age and growth (Avsar, 1995; Ismen, 2002; Samsun et al., 2004; Bilgin et al., 2006; Kalayci et al., 2006; Polat et al., 2008; Sahin et al., 2009), meat yield, abundance and reproduction of these species caught in the Black Sea (Karacam and Duzgunes, 1990; Ismen, 1995; Kideys et al., 1999; Demirel and Yuksek, 2013; Gucu et al., 2016; Gucu et al., 2017). Monitoring the fish stocks is important in order to provide a sustainable data for fisheries management. The aim of this paper is to provide updated data in terms of age, growth and mortality of *Engraulis encrasicolus, Trachurus mediterraneus, Sprattus sprattus, Merlangius merlangus and Mullus barbatus* in the Southeastern Black Sea in order to be able to compare the findings with the previous studies and show fishing pressure in the exploited fish species taking into consideration Marine Strategy Framework Directive (MSFD) (Piet et al., 2010) published by European Commission (2008/56/EC) aimed to reaching Good Environmental Status (GES).

MATERIAL AND METHOD

This study was carried out in 7 sampling stations between 2008 and 2011 fishing seasons. These are Hopa (41°23'15" N – 41°29'32" E, 41° 25'54 N – 41°25'58" E), Rize (41°01'17" N – 40°31'36" E, 41°02'01" N – 40°32'18" E), Trabzon (41°00'05" N – 39°44'12" E, 41°04'55" N – 39°21'24" E), Giresun (40°54'54" N – 38°23'01" E, 40°55'26" N – 38°24'53" E), Ordu (41°03'55" N – 37°46'20" E, 41°03'17" N – 37°47'48" E), Samsun (41°12'44" N – 37°01'44" E, 41°11'21" N – 37°02'21" E) and Sinop (42°01'43" N – 35°09'19" E, 42°01'01" N – 35°08'24" E). Figure 2 represents the sampling stations. The sampled species were *E. encrasicolus* (1588 individuals), *T. mediterraneus* (624 individuals), *M. merlangus* (2292 individuals), *M. barbatus* (2693 individuals) and *S. sprattus* (423 individuals). Samplings were performed with fishing vessel and samples were collected separately. After separation process, species were sampled, weighed and counted. Samples were kept in freezers at -18°C for laboratory studies.

Specimens were collected by bottom trawls using 40 mm mesh size in the cod end, purse seines using 12 -15 mm mesh size in the bunt and gillnets using 34 mm and 36 mm mesh size and 5-6 m depth. The sprat was only caught by purse seine net because this species was mostly found along with European anchovy in the Black Sea. Samplings were shown in according to sampling stations (Table 1).

Total length and weight were measured and weighed within 0.1 cm and 0.01 g with precision in the Karadeniz Technical University, Faculty of Marine Science laboratory. Both otoliths of the species were read to determine age with stereomicroscope (Leica MZ75) on a black background by three different readers.

Regression analyses, statistical calculation and graphs were carried out using Microsoft Office Excel software. Statistical analyses were examined according to Sokal and Rohlf (1973). Differences between groups according to sampling years and stations were determined by one-way analysis of variance ANOVA method. The length-weight relationship was calculated with $W=aL^b$, where a and b are regression coefficient, W is the total weight (g), and L is the total length (cm) (Ricker, 1975). The sex determination was done of each fishes as macroscopic. The Von Bertalanffy growth parameters were calculated using $L_t=L_\infty (1 - e^{-k(t - t_0)})$, where L_∞ is asymptotic length (cm), t is age (year), k is the growth coefficient (year $^{-1}$), and t_0 is the hypothetical age at zero length (year) (Beverton and Holt, 1957; Pauly, 1983; Sparre and Venema, 1992). Age validation was using observed length at age. Sagittal otoliths from each fish species were removed, cleaned and stored in black elisa plates. Age readings were done with a binocular microscope Nikon SMZ 745 T. Age reading were determined from the otolith by two different researchers. The instantaneous total mortality coefficient (Z) was estimated using by the formulae of Z=-lnS (Ricker, 1975), where S is the survival rate (N_1/N_0). Natural mortality rate (M) was estimated by using $M=0.8 \times \exp(-0.0152 - 0.279 \text{ Ln } L_\infty + 0.6543 \text{ Ln } K + 0.463 \text{ LnT})$, where T is the average annual water temperature (°C) in the fishing area which used Black Sea Marine Forecasting Center data (Ricker, 1975; King, 1995). Exploitation rate (E) was estimated from F/Z. Fishing mortality (F) was calculated from F=M-Z (Gulland, 1971).

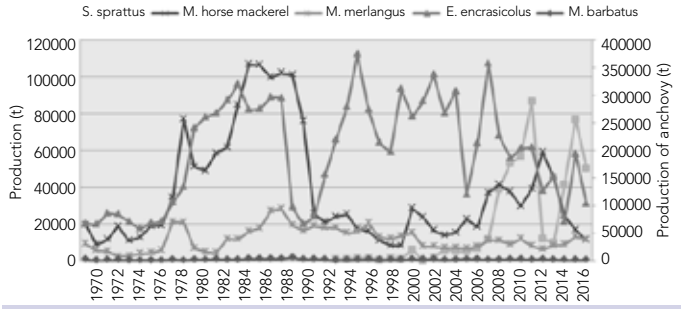

Figure 1. Productions of the species in the Black Sea

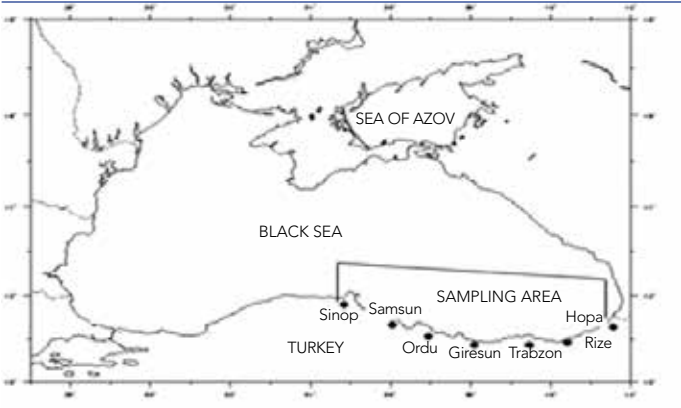

Figure 2. Sampling stations

Table 1. Samplings according to stations and fishing gear.

Station	Gillnets	Purse Seine	Trawl	Total
Hopa	2	3		5
Rize	3	2		5
Trabzon	21	4		25
Giresun	3	2		5
Ordu	3	2	6	11
Samsun	2	1	6	9
Sinop	2	1	2	5
Total	36	15	14	65

RESULTS AND DISCUSSION

In total, 7620 specimens obtained from varied fishing gears on the coast of the Black Sea were examined.

The length-frequency distribution of *E. encrasicolus* was determined from 1588 samples in total. The size ranged between 5.9-15.0 cm with a major distribution fit in between 11 and 12.9 cm (48%). The mean lengths for males (and ±SD), females (and ±SD) and overall samples (and ±SD) were calculated as 10.12±1.389, 10.85±1.449 and 10.64±1.661 cm, respectively. The mean weights for males, females and both sexes were calculated as 8.49±2.941, 7.51±2.932, and 8.16±3.169 g, respectively. Females (59%) were found more abundant than males (36%). The lengths of males and females were found statistically insignificant ($p>0.05$). According to the length-frequency distribution, 19.08% of the *E. encrasicolus* was caught under the minimum landing size (MLS) of 9 cm (Figure 3). *T. mediterraneus* samples (624 units) distributed in a range of 6.2-19.5 cm. The mean lengths for males, females and overall samples were determined as 13.10±2.313, 13.90±2.017 and 12.30±2.824 cm, respectively. About 54.81% of the samples were measured under the MLS. The size of *S. sprattus* out of 423 specimens ranged from 5.6-10.7 cm. The mean lengths for males, females and both sexes were estimated as 7.33±0.916, 7.47±0.903 and 7.35±0.949 cm, respectively. There is no MLS regulation for *S. sprattus* in Turkey. Figure 3 shows the length-frequency distribution of the fish samples in this study. The size of *M. merlangus* samples (2292 units) ranged from 5.9-22.2 cm, and the mean lengths for males, females and overall samples were 12.89±1.937, 13.03±1.895 and 12.70±2.226 cm. The differences between the lengths of this species for males and females were found statistically insignificant ($p>0.05$). 50.57% of *M. merlangus* was caught under the MLS of 13 cm. The MLS was found as 82.58% for *M. barbatus* samples. The length ranged was distributed in 5.3-19.0 cm. The mean lengths for males, females and both sexes were calculated as 11.59±1.323, 11.61±1.665 and 10.55±1.434 cm.

The age of *E. encrasicolus* samples ranged in between 0 and 3. The maximum age group was determined as 3 years for each

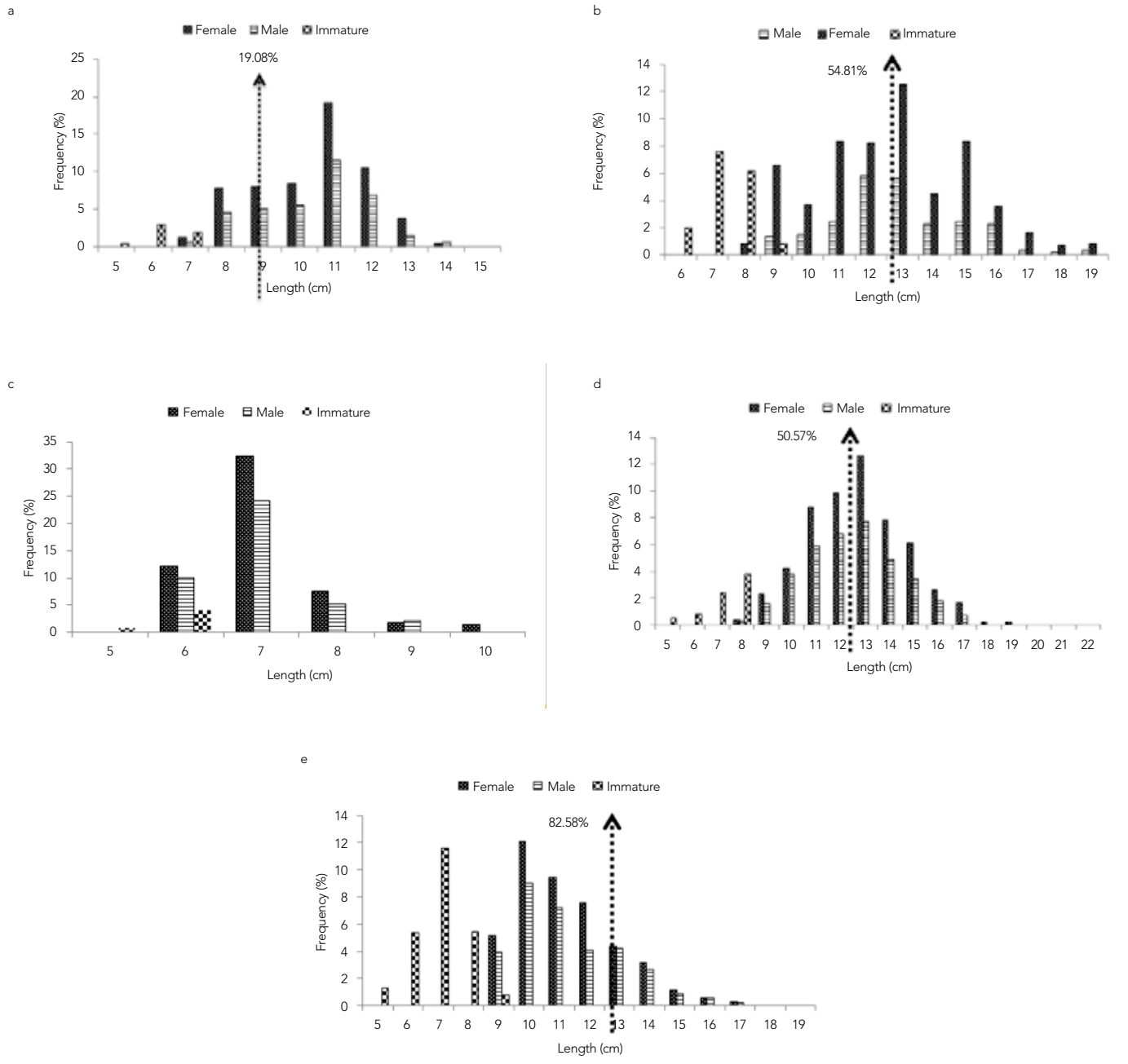

Figure 3. a-e. Length-frequency distribution and rate of below the minimum landing size (MLS) of *E. encrasicolus* (a). *T. mediterraneus* (b). *S. sprattus* (c). *M. merlangus* (d). *M. barbatus* (e)

sex. Females were dominant in each age group. The age of *T. mediterraneus* samples varied in between 0 and 5 years, while it was in a range of 1-4 years for *S. sprattus* samples. The ages of *M. merlangus* and *M. barbatus* samples ranged from 0-4 and 0-5 years, respectively (Table 2, Figure 4).

The length-weight relationships were calculated for each species and were shown in Table 2. The age-length and age-weight relationships of all species were shown in Figure 5 and Table 2 showed age, mean length and weight of each fish species according to sexes.

Von Bertalanffy growth parameters (VBGP) were determined for each species and were shown in Table 3. L_{∞} values were calculated as 16.52 cm for *E. encrasicolus*, 24.26 cm for *T. mediterraneus*, 13.80 cm for *S. sprattus*, 33.05 cm for *M. merlangus* and 24.60 cm for *M. barbatus*. Also, t_0 values were estimated as -2.02 year^{-1}, -2.04 year^{-1}, -1.36 year^{-1}, -2.93 year^{-1} and -1.82 year^{-1}, respectively.

Instantaneous total mortality rate (Z) was determined as 1.27 year^{-1} for *E. encrasicolus*, 1.08 year^{-1} for *T. mediterraneus*, 1.81 year^{-1} for *S. sprattus*, 0.98 year^{-1} for *M. merlangus* and 1.66 year^{-1} for *M. barbatus*. Natural mortality rate (M) was calculated as

Table 2. Age, mean length and weight of *E. encrasicolus, T. mediterraneus, S. sprattus, M. merlangus, M. barbatus*

		Engraulis encrasicolus			*Trachurus mediterraneus*			*Sprattus sprattus*			*Merlangius merlangus*			*Mullus barbatus*		
Age	Sex	N	L (cm)±SD	W (g)±SD	N	L (cm)±SD	W (g)±SD	N	L (cm)±SD	W (g)±SD	N	L (cm)±SD	W (g)±SD	N	L (cm)±SD	W (g)±SD
0	I	81	6.80±0.485	2.13±0.514	106	7.90±0.729	3.87±1.177				65	7.57±0.610	6.82±0.991	655	7.40±0.829	3.83±1.478
	F	251	8.85±0.565	4.81±0.966	88	10.30±0.950	8.76±3.163				86	11.27±0.581	12.67±1.710	117	9.52±0.209	8.24±1.040
	M	157	8.33±0.573	4.50±0.934	17	10.00±0.857	7.86±2.569				57	10.92±0.534	8.05±2.017	88	9.51±1.228	8.33±0.199
	I+F+M	489	8.51±0.934	4.38±1.328	211	8.90±1.335	5.85±2.912				208	10.41±1.161	7.84±2.542	860	7.91±1.158	4.89±2.341
	I							19	6.06±0.142	1.37±0.169						
1	F	441	11.04±0.525	8.87±1.335	184	12.46±0.787	16.13±3.310	51	6.66±0.228	1.74±0.239	728	13.98±0.684	21.95±3.633	839	11.34±1.029	14.49±4.974
	M	278	10.58±0.539	8.26±1.299	91	12.20±0.774	15.69±2.699	40	6.59±0.256	1.67±0.172	442	12.82±0.566	18.53±3.361	622	11.32±0.926	14.47±5.039
	F+M	719	11.03±0.530	8.67±1.321	275	12.40±0.781	15.99±3.131	110	6.52±0.324	1.65±0.254	1170	13.54±0.612	20.11±3.520	1461	11.34±0.987	14.48±4.998
2	F	227	12.45±0.427	11.64±1.633	65	14.55±0.432	23.03±4.389	156	7.69±0.599	2.98±0.752	312	16.04±0.479	32.82±4.215	134	13.92±0.539	27.55±5.259
	M	129	11.69±0.416	10.58±1.558	24	13.49±0.477	22.16±3.215	114	7.84±0.631	2.78±0.792	302	15.22±0.428	23.03±4.224	110	13.77±0.716	26.28±5.334
	F+M	356	12.40±0.422	11.33±1.606	89	14.06±0.447	22.51±3.952	270	7.72±0.607	2.82±0.763	614	15.63±0.455	28.82±4.247	244	13.86±0.598	27.01±5.289
3	F	18	14.08±0.633	17.74±2.649	27	16.73±0.526	32.12±4.551	20	9.72±0.259	6.32±1.178	131	17.89±0.492	38.36±5.962	72	15.33±0.609	34.74±6.152
	M	6	13.80±0.415	15.83±1.962	5	15.54±0.696	30.58±4.298	16	9.70±0.141	5.93±0.071	116	17.13±0.628	33.58±6.195	44	15.42±0.675	35.43±6.850
	F+M	24	13.83±0.485	16.31±2.477	32	15.59±0.581	31.00±4.518	36	9.71±0.219	6.21±0.981	247	17.52±0.553	36.05±6.087	116	15.37±0.623	35.04±6.748
4	F				10	18.30±0.527	51.75±9.279	4	10.47±0.129	7.49±0.512	34	20.02±1.021	70.68±11.04	7	17.44±0.476	52.74±4.334
	M				3	17.55±0.608	46.85±0.535	3	10.11±0.109	7.01±0.261	19	18.99±0.767	58.38±6.825	3	17.47±0.286	51.02±7.627
	F+M				13	17.68±0.599	47.71±8.981	7	10.37±0.121	7.32±0.466	53	19.80±0.922	65.31±9.629	10	17.45±0.369	52.23±6.792
5	F				3	19.30±0.212	58.05±2.584							1	19.0	74.70
	M				1	19.10	52.35							1	19.0	73.43
	F+M				4	19.27±0.207	57.10±3.279							2	19.0	74.07±0.898
Total	F	937	10.85±1.449	8.49±2.941	377	13.90±2.017	20.78±9.728	231	7.47±0.903	2.64±1.259	1291	13.03±1.895	19.29±9.213	1170	11.61±1.665	16.25±11.025
	M	570	10.12±1.389	7.51±2.932	141	13.10±2.313	20.18±11.198	173	7.33±0.916	2.59±1.120	936	12.89±1.937	18.60±9.475	868	11.59±1.323	16.13±10.986
	F+M+I	1588	10.64±1.661	8.16±3.169	624	12.30±2.824	17.68±11.607	423	7.35±0.949	2.53±1.224	2292	12.70±2.226	17.59±9.704	2693	10.55±1.434	13.08±11.327

I: immature; F: female; M: male; SD: standart deviation

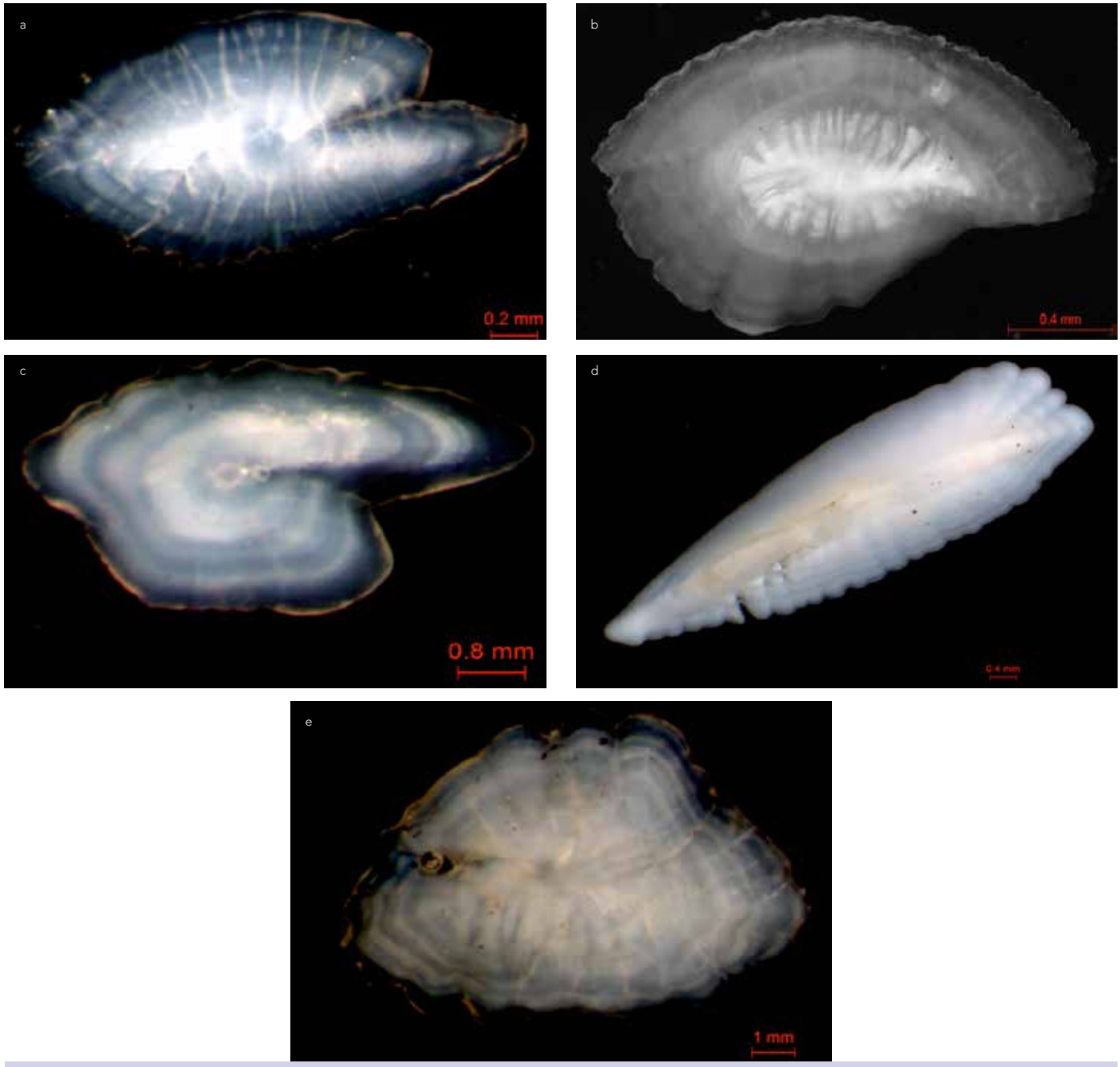

Figure 4. a-e. Otoliths of the *E. encrasicolus* (a: 11.4 cm), *T. mediterraneus* (b: 19.5 cm), *S. sprattus* (c: 6.2 cm), *M. merlangus* (d: 15.5 cm), *M. barbatus* (e: 15.0 cm)

Table 3. The length-weight relationship and Von Bertalanffy growth parameters

Species	a	b± SE	Confidence interval of b	R^2	L∞	k	t_0	Growth model
Engraulis encrasicolus	0.0124	2.711±0.016	2.681-2.746	0.944	16.52	0.36	-2.02	Allometric (-)
Trachurus mediterraneus	0.0050	3.138±0.021	3.099-3.182	0.972	24.26	0.22	-2.04	Allometric (+)
Sprattus sprattus	0.0064	2.921±0.057	2.837-3.006	0.916	13.80	0.25	-1.36	Isometric
Merlangius merlangus	0.0054	3.146±0.021	3.105-3.188	0.919	33.05	0.13	-2.93	Allometric (+)
Mullus barbatus	0.0071	3.124±0.012	3.101-3.148	0.962	24.60	0.22	-1.82	Allometric (+)

SE: standart error

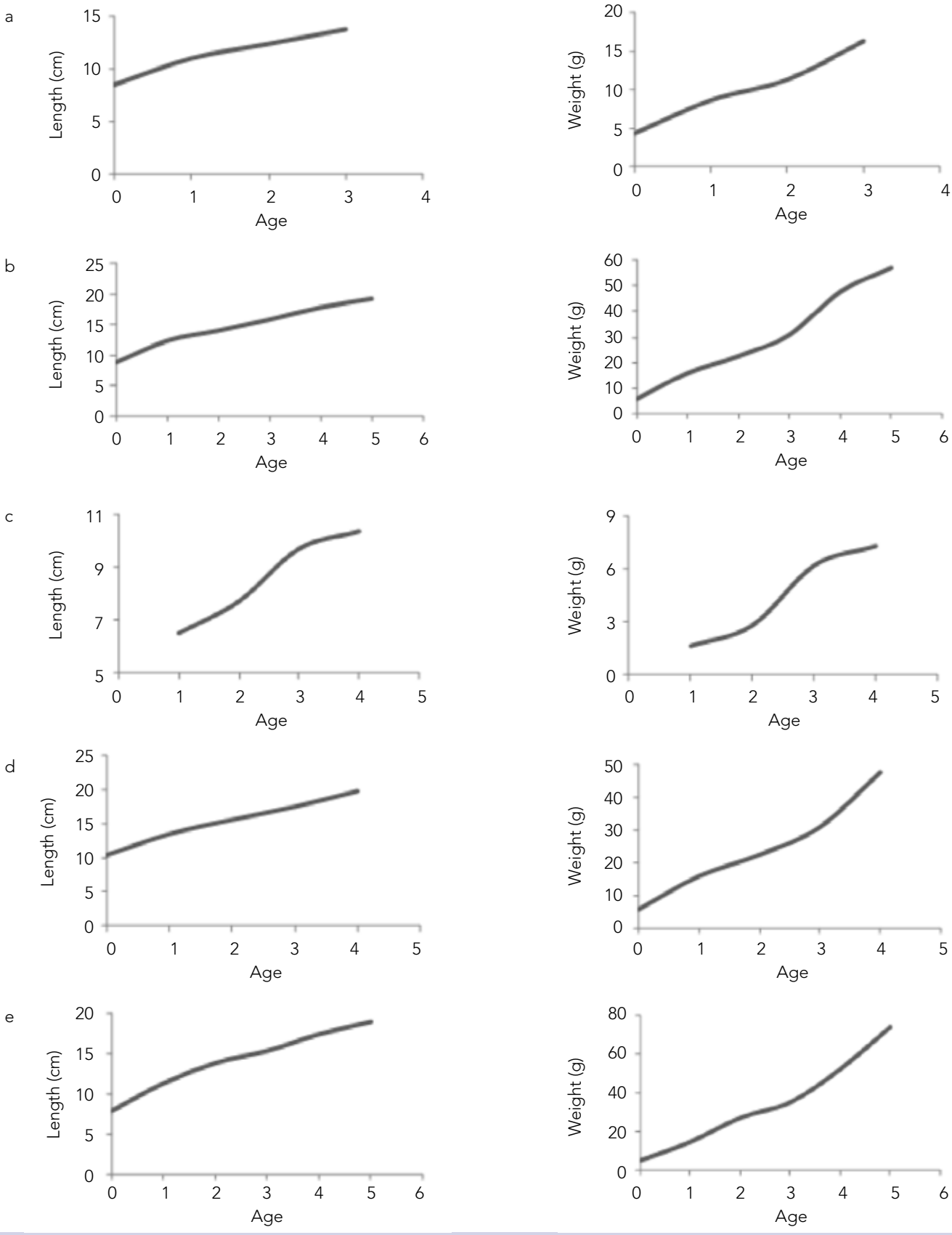

Figure 5. a-e. The age-length and age-weight relationships of all species (a: *E. encrasicolus*. b: *T. mediterraneus*. c: *S. sprattus*. d: *M. merlangus*. e: *M. barbatus*)

0.80 year^{-1}, 0.43 year^{-1}, 0.78 year^{-1}, 0.22 year^{-1}, 0.68 year^{-1}, in same order. Also, fishing mortality rate (F) was also calculated for each species separately. Survival rates were determined 1.27 year^{-1} for *E. encrasicolus*, 0.34 year^{-1} for *T. mediterraneus*, 1.81 year^{-1} for *S. sprattus*, 0.39 year^{-1} *M. merlangus* and 1.66 year^{-1} for *M. barbatus*. Exploitation rates were estimated for 0.37 year^{-1} for *E. encrasicolus*, 0.60 year^{-1} for *T. mediterraneus*, 0.57 year^{-1} for *S. sprattus*, 0.77 year^{-1} for *M. merlangus* and 0.59 year^{-1} for *M. barbatus* (Table 4).

Comparison of the mean length (cm) of 3 species with the highest catch rate according to sampling stations and sampling years and given in Table 5. It was showed that the mean length tend to increase in the Trabzon station and also, the highest mean length was determined in the Samsun station for *E. encrasicolus*. The highest mean length was calculated in Ordu station and the mean length was tended decrease for *M. merlangius* in the Trabzon station. The highest mean length was estimated in the Giresun station and the mean length of it tended to increase for *M. barbatus*. It is remarkable that the mean length of the *M. merlangius* decrease while the mean length of the *M. barbatus* increase for the same station according to years.

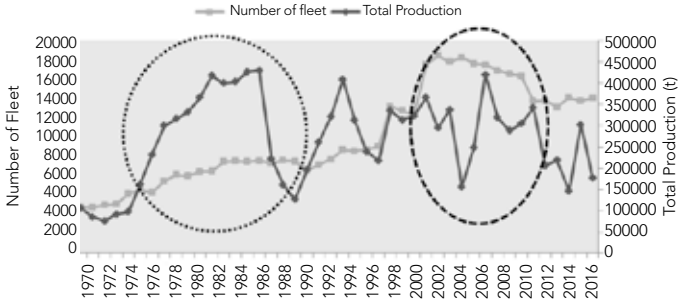

Figure 6. Total Production of these species and number of fleet in Turkey

Table 4. Mortality, survival and exploitation rates of the samples

Species	Z	F	M	S	E
Engraulis encrasicolus	1.27	0.47	0.80	1.27	0.37
Trachurus mediterraneus	1.08	0.65	0.43	0.34	0.60
Sprattus sprattus	1.81	1.03	0.78	1.81	0.57
Merlangius merlangus	0.98	0.76	0.22	0.39	0.77
Mullus barbatus	1.66	0.98	0.68	1.66	0.59

F: female; M: male

In this study, age, growth and mortality rates were determined for 5 economically important fish species caught from the Black Sea in 2008-2011 fishing season. *E. encrasicolus* is the most important fish for the Turkish fisheries sector. The mean length of *E. encrasicolus* in this study was found as 10.64 cm, which is close to the previous findings for this species caught from the same region by Samsun et al. (2006), however, the lower results were obtained in different years by Sahin et al. (2009) and Bacha et al. (2010). The lower mean lengths obtained in the previous studies can be explained with the dramatic change in fisheries in this region due to abundance of *Mnemiopsis leidyi*, overfishing and the use of different fishing gears in Turkish fisheries. The similar age groups were observed in the previous studies on European anchovy caught in the same area. The results of the growth parameters were compared with the early studies by Karacam and Duzgunes (1990), Samsun et al. (2006), Sahin et al. (2006). The mortality rate parameters in this study are the lower than those by Samsun et al. (2006) in the Black Sea, and Adriatic Sea by Sinovcic (2000). The high demand of the anchovy for fish meal and oil industry and using non-selective fishing gears creates fishing pressure of this species in purse seine operations in the Black Sea fisheries. In addition to this, the Black Sea ecosystem was destroyed by invader species just as *Mnemiopsis leidyi* which is caused great damage anchovy stocks (Chashchin, 1996; Gucu, 2002; Tutar, 2014; Gucu et al., 2017).

Based on catch statistics, *T. mediterraneus* is accepted as an important fish species for Turkish fisheries. According to the length groups, the majority of the samples (55%) were found shorter than MLS of 13 cm. The ages in this study did not sup-

Table 5. Comparison of the mean length (cm) of most caught species according to sampling stations and sampling years in the southeastern Black Sea

Stations	*E. encrasicolus*			*M. merlangus*			*M. barbatus*		
	2009	2010	2011	2009	2010	2011	2009	2010	2011
Hopa	-	11.66±0.89^{a}	-	-	14.53±3.39^{xy}	-	-	12.02±1.66^{kl}	-
Rize	11.99±1.15^{a}	-	-	15.04±1.07^{x}	-	-	13.13±1.27^{k}	-	-
Trabzon	10.02±1.98^{bB}	11.01±0.99^{bA}	11.13±0.13^{A}	13.52±2.17^{yX}	12.06±1.08^{cY}	12.18±0.84^{Y}	8.50±3.07^{lM}	11.60±1.95^{lL}	13.16±0.14^{K}
Giresun	-	-	-	15.03±1.01^{x}	-	-	13.74±0.31^{k}	-	-
Ordu	-	-	-	15.33±1.44^{xX}	13.41±1.40^{yY}	-	-	-	-
Samsun	-	12.15±0.21^{a}	-	-	13.99±2.11^{xy}	-	-	12.90±0.36^{kl}	-
Sinop	-	-	-	-	14.30±2.17^{x}	-	-	12.84±1.37^{k}	-

*Values are expressed as mean±SD. Mean values (cm) with different lower case superscripts in column and row were significantly different according to sampling years ($p<0.05$) and mean values (cm) with different upper case superscripts in row were significantly different according to sampling stations ($p<0.05$)

port the findings by Aydin and Karadurmus (2012). The differences may be caused misreading of otoliths by the previous studies. The growth parameters of *T. mediterraneus* in this study are close to the findings by Ozdemir et al. (2009) and Sahin et al. (2009), while the values were higher than the results by Yankova and Raykov (2012), and Yankova (2013). The higher growth parameters are clarified with the different sampling areas and the sampling methods in these studies. The fishing mortality rate was determined as 0.65 $year^{-1}$. This rate was found lower than that in the other studies carried out in this region (Sahin et al., 2009; Ozdemir et al., 2009; Yankova and Raykov, 2012; Yankova, 2013).

The mean length of *S. sprattus* was found as 7.35 cm and this value was lower than that in the past studies by Sahin (1999) (10.69 cm). These results can be explained by overfishing of this species; that's, it is caught by purse seine nets along with European anchovy. The ages (1-4 years) of this species was similar to the findings by Sahin (1999), with an exception of Avsar (1995) (0-5 years). Growth and mortality parameters also supported the results by Avsar (1995) for this species caught in the same region in different years.

According to the fishery regulations in Turkey, MLS of *M. merlangus* is 13 cm in total length (MFAL, 2012). The mean total length of whiting was calculated as 12.70 cm which was below the MLS. The findings for the whiting were supported the values by Erdogan Saglam and Saglam, (2012). While the values were lower than the ones reported by Sahin and Akbulut (1997), Ciloglu et al. (2001), Ismen (2002), for this species, they were higher than the values of Maximov et al. (2011). Four ages were observed for *M. merlangus* for males and females, which was lower than the values reported in the previous studies carried in the same area in different years (Sahin and Akbulut, 1997; Ciloglu et al., 2001; Erdogan Saglam and Saglam, 2012; Ismen, 2002; Maximov et al., 2011). L_{∞} value of *M. merlangus* was lower than the results given by the recent studies. Natural mortality value (M) was calculated in this research as 0.22 yr^{-1}, which was lower than Erdogan Saglam and Saglam (2012). Total mortality rate (Z) and fishing mortality (F) rate were found lower than Ismen (2002) those and higher than Maximov et al. (2011).

M. barbatus is a commercial demersal fish species and is caught by bottom trawl and bottom gillnets. Eighty three percent of the samples distributed under the MLS of 13 cm for *M. barbatus*. The results can be clarified by the effect of overfishing of this species like the others in the Black Sea. *M. barbatus* samples distributed in a range of 0-5 age groups. Genc (2000) reported maximum 9 years for females and 8 years for males. Ozbilgin et al. (2004) observed the samples between 1 and 5 years, while Akyol et al. (2000) and Celik and Torcu (2000) found them as 1-4 years, Mete (2005) and Kinacigil et al. (2001) as 1-3 years, and Becer Ozvarol et al. (2006) 0-6 years. Growth parameter values of *M. barbatus* in this study were close to the results by Ozbilgin et al. (2004). The mortality rate of this species was found lower than that in the other studies carried out in this region. Total mortality rate (1.30 $years^{-1}$) was lower than that by Ozbilgin et al. (2004), but it was higher than by Aksu (2011).

The reasons of high mortality rates and low mean length of this species can be explain changing of the Black Sea condition, global warming, introducing invasive species and increasing number of fishing vessels in Turkey. Because development of the fishing fleet has generated fishing pressure in the exploiting fish species and other stocks since early 1980. In the forthcoming years, this pressure had gone further and dramatic decrease observed in fishing stocks in 1988. The same trend is still observing nowadays. There are inverse relationship between two terms and shown in Figure 6. According to 3rd Task group "Commercially Exploited Fish and Shellfish" in Marine Strategy Framework Directive (MSFD), mentioned that a healthy stock represents proportion older and larger fish in the population as an indicator reaching the Good Environmental Status (GES) (Piet et al., 2010). Nowadays, we cannot found older size and age of the commercial fish species. It is show that the evidence of the unhealthy and unsustainable stocks in the Black Sea Fisheries. The same advices and precautions were made in EU Common Fishery Policy and Ecosystem Based Fishery Management (Pikitch et al., 2004).

CONCLUSION

This paper represents an updated data on age, growth and mortality rate of five commercial fish species living in the coast of the Turkish Black Sea. The results of this research can be a baseline for researchers in the future. Monitoring research is essential for the exploited fish stocks in the Black Sea fisheries. The results of this study can be a guide to Ministry of Food, Agriculture and Livestock in order to improve their regulation measures, limitation of the fishing fleet and re-evaluation of the minimum landing size of economically important fish species for the sustainable fisheries.

ACKNOWLEDGEMENT

This article has been prepared using data obtained by a project supported by the Karadeniz Technical University Scientific Research Fund (2008.117.001.1).

REFERENCES

Aksu, H., Erdem, Y., Ozdemir, S., Erdem, E. (2011). Estimation of some population parameters of red mullet (*Mullus barbatus ponticus*, Essipov, 1927) caught in the Black Sea. *Journal of FisheriesSciences.com* 5, 345-353.

Akyol, O., Tosunoglu, Z., Tokac, A. (2000). Investigations of the growth and reproduction of red mullet (*Mullus barbatus* Linnaeus, 1758) population in the Bay of Izmir (Aegean Sea). *Anadolu University Journal of Science and Technology* 1, 121-127.

Avsar, D. (1995). Population parameters of sprat (*Sprattus spratus phalericus* Risso) from the Turkish Black Sea Coast. *Fisheries Research* 21: 437-453. [CrossRef]

Aydin, M. and Karadurmus, U. (2012). Age, growth, length-weight relationship and reproduction of the Atlantic horse mackerel (*Trachurus Trachurus* Linnaeus, 1758) in Ordu (Black Sea). *Ordu University Journal of Science and Technology* 2, 68-77.

Bacha, M., Moali, A., Benmansour, N.E., Brylinski, J.M., Mahé, K., Amara, R. (2010). Relationships between age, growth, diet and environmental parameters for anchovy (*Engraulis encrasicolus* L.) in the Bay of Bénisaf (SW Mediterranean, West Algerian Coast). *Cybium* 34, 47-57.

Becer Ozvarol, Z.A., Balci, B.A., Ozbas, M., Gokoglu, M., Gulyavuz, H., Tasli, A., Pehlivan, M., Kaya, Y. (2006). An investigation on the growth properties of red mullet (*Mullus barbatus* L., 1758) in Antalya Bay. *Ege University Journal of Fisheries and Aquatic Science* 23: 113-118.

Beverton, R.J., Holt, S.J. (1957). On the Dynamics of Exploited Fish Populations. *Fisheries Investment Series 2*, Vol 19 Ministry of Agriculture and Fisheries 533 pp. 126.

Bilgin, S., Samsun, N., Samsun, O., Kalayci, F. (2006). Estimation of population parameters of anchovy, Engraulis encrasicolus L. 1758, at 2004-2005 fishing season in The Middle Black Sea, using length frequency analysis methods. *E.U. Journal of Fisheries & Aquatic Sciences* 23, 359-364.

Chashchin, A.K. (1996). The Black Sea populations of anchovy. *Sci Mar* 60, 219-225.

Celik, O., Torcu, H. (2000). Investigations on the biology of red mullet (*Mullus barbatus* Linnaeus, 1758) in Edremit Bay, Aegean Sea, Turkey. *Turkish Journal of Veterinary and Animal Sciences* 24, 287-295.

Ciloglu, E., Sahin, C., Zengin, M., Genc, Y. (2001). Determination of some population parameters and reproduction period of whiting (Merlangius merlangus euxinus, Nordmann, 1840) on the Trabzon-Yomra coast in the Eastern Black Sea. *Turkish Journal of Veterinary and Animal Science* 25, 831-837.

Daskalov, G.M., Grishin, A.N., Rodionov, S., Mihneva, V. (2007). Trophic cascades triggered by overfishing reveal possible mechanisms of ecosystem regime shifts. *PNAS* 104, 10518-10523. [CrossRef]

Demirel, N. and Yüksek, D. (2013). Spawning Frequency of Trachurus mediterraneus (Carangidae) in The Sea of Marmara. *Turkish Journal of Fisheries and Aquatic Sciences* 13, 441-446. [CrossRef]

Erdogan Saglam, N. and Saglam, C. (2012). Population parameters of whiting (*Merlangius merlangus euxinus* L., 1758) in the South-Eastern Black Sea. *Turkish Journal of Fisheries and Aquatic Sciences* 12, 831-839.

Froese, R., Pauly, D. (2012). *FishBase.* Available from: http://www.fishbase.org/summary/Merlangius-merlangus.

Georgieva, D.P. and Konsulov, A. (1993). On the distribution of the New Ctenophora Species Mnemia mccradyi in the Black Sea along the Bulgarian coastline in summer 1990. *In: Bulgarian Academy of Science,* Vol 46:3.

Genc, Y. (2000). Population parameters and bio-ecological features of the red mullet (*Mullus barbatus ponticus*, Ess. 1927) stocks from the Eastern Black sea coast of Turkey. Dissertation, Karadeniz Technical University.

Gucu, A.C. (2002). Can Overfishing be Responsible for the Successful Establishment of Mnemiopsis leidy in the Black Sea. *Estuar Coast Shelf Sci* 54, 439-451. [CrossRef]

Gucu, A.C., Inanmaz, O.E., Ok, M., Sakinan, S. (2016). Recent changes in the spawning grounds of Black Sea anchovy, Engraulis encrasicolus. *Fish Oceanogr* 25, 67-84. [CrossRef]

Gucu, A.C., Genc, Y., Dagtekin, M., Sakinan, S., Ak, O., Ok, M., Aydin, I. (2017). On Black Sea Anchovy and Its Fishery. *Reviews in Fisheries Science & Aquaculture* 25, 230-244. [CrossRef]

Hureau, J.C. (1986). *Mullidae.* In: Whitehead PJP, Bauchot ML, Hureau JC, Nielsen J, Tortonese E (ed) Fishes of the North-eastern Atlantic and the Mediterranean. Paris: UNESCO, pp. 16.

Ismen, A. (1995). Fecundity of whiting, Merlangius merlangus euxinus (L.) on the Turkish Black Sea coast. *Fisheries Research* 22, 309-318. [CrossRef]

Ismen, A. (2002). A preliminary study on the population dynamics parameters of whiting (Merlangius merlangus euxinus) in Turkish Black Sea coast waters. *Turkish Journal of Zoology* 26, 157-166.

Ivanov, L. and Beverton, R.J.H. (1985). *The fisheries resources of the Mediterranean.* Part 2: Black Sea GFCM. Studies and Reviews 60, pp. 135.

Kalayci, F., Bilgin, S., Samsun, O., Samsun, N. (2006). Researching the place of fisheries industry and general state of the sprat (Sprattus sprattus Phalericus Risso, 1826) fishing Middle Black Sea Region. *E.U. Journal of Fisheries & Aquatic Sciences* 23, 449-455.

Karacam, H. and Duzgunes, E. (1990). Age, growth and meat yieldof the European anchovy (Engraulis encrasicolus, L. 1758) in the Black Sea. *Fisheries Research* 9, 181-186. [CrossRef]

Kasapoglu, N., Sahin, A., Duzgunes, E. (2009). Investigations of the some population parameters of anchovy (*E. encrasicolus*) encrasicolus in the Eastern Black Sea. 15. National Fisheries Symposium, 1-4 July 2009, Rize, Turkey (Turkish).

Kideys, A.E. (1994). Recent dramatic changes in the Black Sea ecosystem: The reason for the sharp decline in Turkish anchovy fisheries. *Journal of Marine System* 5, 171-181. [CrossRef]

Kideys, A.E., Gordina, A.D., Bingel, F., Niermann, U. (1999). The effect of environmental conditions on the distribution of eggs and larvae of anchovy (Engraulis encrasicolus L.) in the Black Sea. *ICES Journal of Marine Science* 56, 58-64. [CrossRef]

Kinacigil, H.T., İlkyaz, A.T., Akyol, O., Metin, G., Cira, E., Ayaz, A. (2001). Growth parameters of red mullet (*Mullus barbatus*) and seasonal codend selectivity of traditional bottom trawl nets in İzmir Bay (Aegean Sea). *Acta Adriatica* 42, 113-123.

Mater, S., Kaya, M., Bilecenoglu, M. (2002). *Atlas of Turkish marine fishes.* Ege University Faculty of Fisheries Publication, 68 pp.169 (in Turkish).

Maximov, V. and Staicu, I. (2007). Evolution of Demersal Fish Species Catches from the Romanian Marine Area between 2000 and 2007. INCDM Constanta, *Cercetari Marine /Recherches Marines*, 38, 305.

Maximov, V., Raykov, V.S., Yankova, M., Zaharia, T. (2011). Whiting (*Merlangius merlangus euxinus*) population parameters on the Romanian and Bulgarian littoral between 2000-2008. *Journal of Environmental Protection and Ecology* 12, 1608-1618.

Mete, T. (2005). *Investigating of some growth features of red mullet (Mullus barbatus L. 1758) distributing in Mersin Bay.* Dissertation, Ankara University.

Ministry of Food, Agriculture and Livestock (MFAL), 2012. *Fishery Circular.* Ankara Turkey 112 pp.

Ozbilgin, H., Tosunoglu, Z., Bilecenoglu, M., Tokac, A. (2004). Population parameters of *Mullus barbatus* in İzmir Bay (Aegean Sea), using length frequency analysis. *Journal of Applied Ichthyology* 20, 231-233. [CrossRef]

Ozdemir, S., Erdem, E., Ozdemir, Z.B., Sahin, D. (2009). Estimation of population parameters from length composition of pelagic species caught in the Black Sea: horse mackerel (*Trachurus trachurus*), bluefish (*Pomatomus saltatrix*) and allis shad (*Alosa alosa*). *Fırat University Journal of Science* 21, 1-8 (in Turkish).

Pauly, D. (1983). Some simple methods for the assessment of tropical fish stocks. FAO Fisheries Technical Paper, Rome.

Piet, G.J., Albella, A.J., Aro, E., Farrugio, H., Lleonart, J., Lordan, C., Mesnil, B., Petrakis, G., Pusch, C., Radu, G., Ratz, H.J. (2010). *Commercially exploited fish and shellfish.* Task Group 3 Report of marine Strategy Framework Directive. JRC Technical and Scientific Reports. Italy. ISBN 978-92-79-15500-0. DOI 10.2788/83073.

Pikitch, E.K., Santora, C., Babcock, E.A., Bakun, A., Bonfil, R., Conover, D.O., Livingston, P.A., Mangel, M., McAllister, M.K., Pope, J. and Sainsbury, K.J. (2004). Ecosystem-based fishery management. *Science* 305, 346-347. [CrossRef]

Polat, N., Pısıl, Y., Yılmaz, S. (2008). Age determination with some bony structures and length-frequency method of sprat (Sprattus sprattus L.,1758) in the Black Sea. *Journal of FisheriesSciences.com* 2, 126-33. [CrossRef]

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

Sahin, C., Gozler, A.M., Hacimurtazaoglu, N., Kongur, N. (2006). Stock structure of Eastern Black Sea anchovy (*Engraulis encrasicolus*, L.,

1758). *Ege University Journal of Fisheries and Aquatic Sciences* 23, 497-503.

Sahin, C., Kasapoglu, N., Gozler, A.M., Kalayci, F., Hacimurtazaoglu, N., Mutlu, C. (2009). Age, growth, and gonadosomatic index (GSI) of Mediterranean horse mackerel (*Trachurus mediterraneus* Steindachner, 1868) in the Eastern Black Sea. *Turkish Journal of Zoology* 33, 157-167.

Sahin, T. (1999). Some biological characteristics of sprat (*Sprattus sprattus phalericus* Risso, 1826) on the Eastern Black Sea coast. *Turkish Journal of Zoology* 23, 249-255.

Sahin, T. and Akbulut, B. (1997). Some population aspects of whiting (*Merlangius merlangus euxinus*, Nordmann, 1840) in the Eastern Black Sea coast of Turkey. *Turkish Journal of Zoology* 21, 187-193.

Samsun, O., Samsun, N., Karamollaoglu, A.C. (2004). Age, growth, and mortality rates of the European anchovy (*Engraulis encrasicolus* L. 1758) off the Turkish Black Sea coast. *Turkish Journal of Veterinary and Animal Science* 28, 901-910.

Samsun, O., Samsun, N., Kalayci, F., Bilgin, S. (2006). A Study on Recent Variations in the Population Structure of European Anchovy (*Engraulis encrasicolus* L., 1758) in the Southern Black Sea. *E.U. Journal of Fisheries & Aquatic Sciences* 23, 301-306.

Shulman, G.E. (1974). Life cycles of fish. Physiology and biochemistry. New-York: Hulsted Press John Wiley and Sons, 253 p.

Sokal, R.R. and Rohlf, F.J. (1973). Introduction to biostatistics. San Francisco: Freeman, 554 p.

Sparre, P., Venema, S.C. (1992). Introduction to tropical fish stock assessment Part 1-Manual. FAO Fisheries Technical Paper 306, 376 p.

Torstensen, E. (1992). Fecundity studies on sprat, *Sprattus sprattus* L., from a fjord on the Norwegian Skagerrak coast. *Flødevigen rapportser* 1, 1-16.

Turkish Statistical Institute (TSI), 2017. Fishery Statistics. Ankara, Turkey.

Tutar, O. (2014). Stock Assessment of The Black Sea Anchovy. Master of Science, Graduate School of Marine Sciences, Middle East Technical University, 88 pages.

Whitehead, P.J.P. (1985). FAO species catalogue. Clupeoid fishes of the world. An annotated and illustrated catalogue of the herrings, sardines, pilchards, sprats, anchovies and wolfherrings. vol. 7 part 1 Chirocentridae, Clupeidae and Pristigasteridae. FAO Fish. Rome no 125.

Yankova, M. (2013). A study on the growth of horse mackerel (*Trachurus mediterraneus* Aleev, 1956) from Bulgarian waters of the Black Sea using length frequency analysis. *Journal of Black Sea/Mediterranean Environment* 19, 111-120.

Yankova, M., Pavlov, D., Raykov, V. (2009). Population dynamics of horse-mackerel (*Trachurus mediterraneus*), as a valuable economic species for the Bulgarian Black Sea coast. *The Annals of the University Dunarea de Jos of Galati, International Symposium Euro Aliment*, Galati.

Yankova, M. and Raykov, V. (2012). Growth, mortality and yield per recruit of horse mackerel (*Trachurus mediterraneus*) from the Bulgarian Black Sea waters. *Journal of Environmental Protection and Ecology* 13, 1817-1823.