TÜBİTAK

Research Article

Turk J Zool
34 (2010) 85-92
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doi:10.3906/zoo-0811-10

Growth and length-weight relationships of the horse mackerel, *Trachurus mediterraneus ponticus* (Aleev, 1956), off the Bulgarian Black Sea coast

Maria Hristova YANKOVA[1,*], Violin Stoyanov RAYKOV[1], Dimitar Borisov GERDZHIKOV[1], Petya Bogomilova FRATEVA[2]

[1]Institute of Fishing Resources, Department of Ichthyology, P.O. Box 72, 4 Primorski Blvd., 9000, Varna, BULGARIA

[2]Professional Technical School, Plovdiv, BULGARIA

Received: 11.11.2008

Abstract: Between April 2007 and October 2008 we collected 1995 horse mackerel specimens from the territorial waters of the Bulgarian Black Sea. Age, length, and weight of these specimens were determined to estimate length-weight relationships and age composition. The present study utilized otolith characterization to determine age. The sex ratio was 1:1.36686 (M:F). The prevalent age classes were 2+, 3+, and 4+. The exponent *b* of equation resulted in the value 3.3046, which indicates that the weight growth is positive allometric. Growth parameters of the von Bertalanffy equation were separately evaluated for females and males as follows: $L_\infty = 19.66$, $K = 0.3075\ y^{-1}$, $t_o = -0.8359$, and $W_\infty = 69.676$, and $L_\infty = 18.78$, $K = 0.3373\ y^{-1}$, $t_o = -0.8247$, and $W_\infty = 62.037$, respectively. The maximum age was 6+ years for females and 5+ for males.

Key words: Horse mackerel, *Trachurus mediterraneus ponticus*, growth, Black Sea, Bulgaria

Introduction

Three fish species from the Black Sea pelagic community are recognized as the most important commercially and ecologically: Black Sea sprat, anchovy, and horse mackerel (Raykov and Yankova, 2008). Horse mackerel, *Trachurus mediterraneus ponticus* (Aleev, 1956), is a major commercial fishery for the waters of the Black Sea and belongs to the family Carangidae. This family is represented by 200 species that are widely distributed in tropical, subtropical, and moderate areas of all oceans and adjoining seas (Valkanov et al., 1978). Only *Trachurus mediterraneus ponticus* is distributed in the territorial waters of the Bulgarian Black Sea. The entrance of separate *Trachurus trachurus* specimens in the Black Sea waters of the Marmara region is quite a rare phenomenon (Stoyanov et al., 1963). Biological characteristics of horse mackerel in the Black Sea have been well characterized by many researchers.

The biology of this species along the Romanian coast of the Black Sea has been previously reported by Cautis and Jonescu (1979). Ambroaz (1954)

* E-mail: maria_y@abv.bg

investigated the distribution, migratory patterns, and catch composition. Prodanov et al. (1997) studied growth and estimated the optimal level of exploitation of horse mackerel along the Bulgarian coast. Yankova and Raykov (2006) reported data for the growth parameters and natural mortality coefficient of this species. Despite the significant number of studies on horse mackerel, little is known regarding the growth of *Trachurus mediterraneus ponticus* along the Bulgarian Black Sea coast. Growth is an important component of fish ecology, especially during early life history stages (Sogard, 1994; Claramunt and Wahl, 2000).

Determination of age and growth rate is very important in ichthyologic investigations, as fish growth is one of the main factors that determine stock conditions (Mikhailov and Prodanov, 1983). Parameters obtained from the length-weight equation are utilized in several practical applications, such as the rapid conversion of the length of an individual fish to weight (so as to assess the size of a population or standing stock), estimation of the mean weight of fish in a given length class, as well as studies of mortality rates, exploitation rates, and other key parameters important for the precise characterization of fish populations (Sinovčič, 2003).

Environmental fluctuations are thought to strongly influence the abundance of pelagic species and may also result in life cycle and growth pattern changes; therefore, data gathered from long-term studies are critical for determining average growth parameters (Bellido et al., 2000). The present study contributes to the body of information regarding growth, age, and length-weight composition of horse mackerel in Bulgarian Black Sea waters.

Materials and methods

Specimens (n = 1995) were collected between April 2007 and October 2008 from 2 ports located on the Black Sea (Varna and Bourgas) (Figure 1). Fish samples were caught by mid-water trawl with 6.5 mm codend mesh. The captured fish were transported immediately on ice to the laboratory for analysis. Total length (TL) was measured to the nearest 0.1 cm and body weight to the nearest 0.1 g. The present study

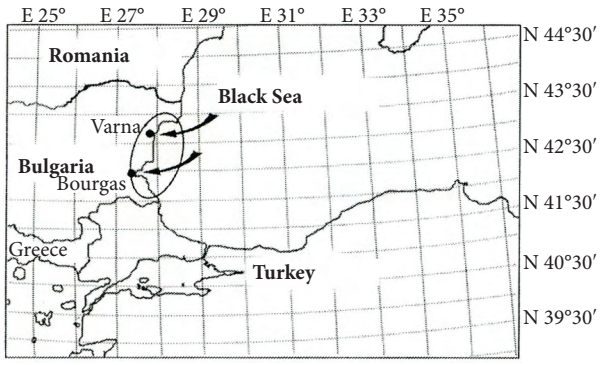

Figure 1. Study areas.

used otoliths to determine age, which was determined from otolith rings, as previously described by Pravdin (1966). Otoliths removed from the fish were stored dry in paper envelopes, and were then examined in glycerin under a digital microscope (Microbiotest, Ltd.). Two independent observations of each sample were performed with reflected lights and unreadable otoliths were eliminated from age determination. Von Bertalanffy (1938) growth equations were used to describe the growth of the species:

$$L_t = L_\infty \left\{1 - \exp\left[-k(t-t_0)\right]\right\}$$

$$W_t = W_\infty \left\{1 - \exp\left[-k(t-t_0)\right]\right\}^n$$

where L_t is total length at age t, L_∞ is asymptotic total fish length, W_∞ is asymptotic total weight, K is the growth curvature parameter and coefficient, t_o is the hypothetical time when the length of the fish is zero, and t is the fish age (years).

Value t_o is calculated as follows:

$$t_0 = \frac{\left[a - \ln(L_\infty)\right]}{k}$$

The length-weight relationship of horse mackerel was estimated with the following equation:

$W = aL^b$ (Ricker, 1975),

where W is total body weight (g), L is total length (cm), a is a coefficient related to body form, and b is an exponent indicating isometric growth when equal to 3.

The sex ratio was analyzed using the chi-square (χ^2) test to indicate whether there was a deviation from a 1:1 ratio. The significance of any difference in population parameters was tested by analysis of variance (ANOVA).

Results

Length distribution

Distribution of total length classes (TL) of the horse mackerel *Trachurus mediterraneus ponticus* is presented in Figure 2. Mean length of the fish examined ranged from 10.5 to 17.0 cm.

Age composition, sex distribution, and growth

The age composition of males and females was 1-5+ and 0-6+ respectively (Figure 3). Three-year-old specimens were the most abundant age group in the entire sample. Additionally, 2-year-old males were the most numerous, while age groups of 0 and 6 were completely absent. In females the complete range of ages was observed (0-6 age classes), with a prevalence of age classes 3+ and 4+. Of the fish examined, 1152 (57.74%) were female and 843 (42.26%) were male. The overall ratio of females to males was 1:1.36686 (M: F) and χ^2 analysis showed this to be significant ($P < 0.05$) (Table 1). The 2+, 3+, and 4+ age groups were the most abundant in the samples from the Black Sea during the investigation period (Figure 3).

Length-weight relationships

The length-weight relationships were separately evaluated for females, males, and both sexes combined (Table 2). The exponent b ranged between

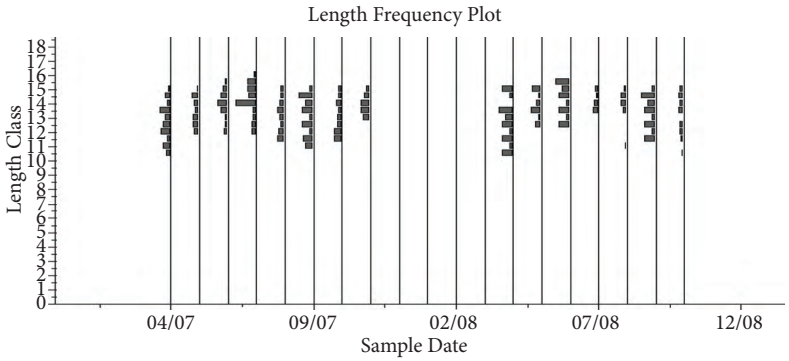

Figure 2. Histogram of length frequency data.

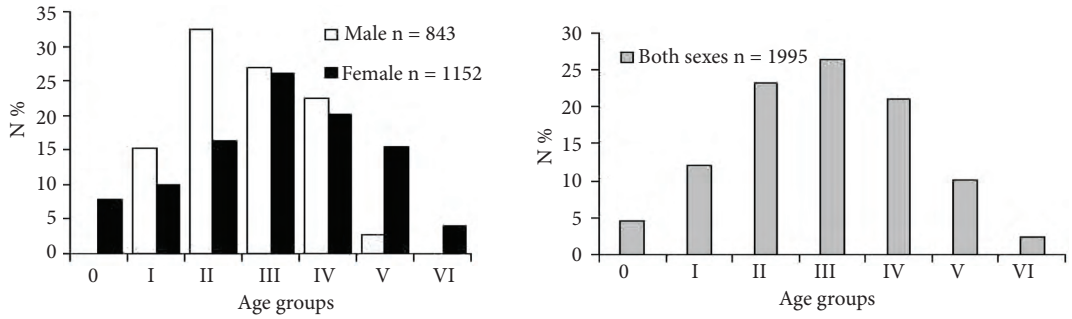

Figure 3. Age structure of horse mackerel males, females, and both sexes combined during the study period in Bulgarian Black Sea territorial waters.

Table 1. Age-sex composition.

Age group	Total		Male		Female		Sex ratio	P = 0.05
	n	%	n	%	n	%		
0	119	5.96	29	1.45	90	4.51	1:3.22	P < 0.05
I	214	10.73	99	4.96	115	5.76	1:1.22	P < 0.05
II	463	23.21	274	13.73	189	9.47	1:0.69	P < 0.05
III	527	26.42	227	11.38	300	15.04	1:1.32	P < 0.05
IV	422	21.15	190	9.52	232	11.63	1:1.22	P < 0.05
V	203	10.17	24	1.2	179	8.97	1:7.47	P < 0.05
VI	47	2.35			47	2.35		-
Total	1995	100	843	42.26	1152	57.74		

Figure 2. Histogram of length frequency data.

	N	a	b	P = 0.05	
Females	1152	0.0038	3.3029	0.9100	P < 0.05
Males	843	0.0034	3.3123	0.9235	P < 0.05
All fish	1995	0.0035	3.3046	0.9084	P < 0.05

3.3029 for females and 3.3123 for males, exhibiting positive allometric growth. There was not a significant difference when the length-weight relationships of the sexes were compared using covariance (P > 0.05).

The von Bertalanffy growth curves

The growth equations for females, males, and total sample were as follows:

$$L_t = 19.661\{1-\exp[-0.2940(t+0.8359)]\};$$

$$L_t = 18.785\{1-\exp[-0.3373(t+0.8247)]\};$$

and

$$L_t = 19.725\{1-\exp[-0.3020(t+0.8305)]\}.$$

The growth in length of horse mackerel females, males, and both sexes combined are presented in Figure 4. During the first 3 years of life females and males differed in length. Males were characterized by higher growth rates than females. The von Bertalanffy growth parameters calculated using mean total weights were as follows:

$$W_t = 69.676\{1-\exp[-0.2994(t+0.7409)]\}^{3.3029};$$

$$W_t = 62.037\{1-\exp[-0.2940(t+0.2308)]\}^{3.3123};$$

and

$$W_t = 71.888\{1-\exp[-0.2714(t+0.5843)]\}^{3.3046}$$

for females, males, and both sexes, respectively. Females had a higher theoretical maximum weight than males (Table 3) and growth rates based on weight calculated with the von Bertalanffy model are presented in Figure 5.

Discussion

Total length of the horse mackerel samples ranged from 10.5 cm to 17.0 cm. This range differs from those reported by Şahin et al. (1997) and Genç et al. (1999) for horse mackerel populations of the Turkish Black Sea coast (7.4-14.5 cm) and the Eastern Black Sea (6.5-19 cm), respectively. There were, however, differences in mean length values between the

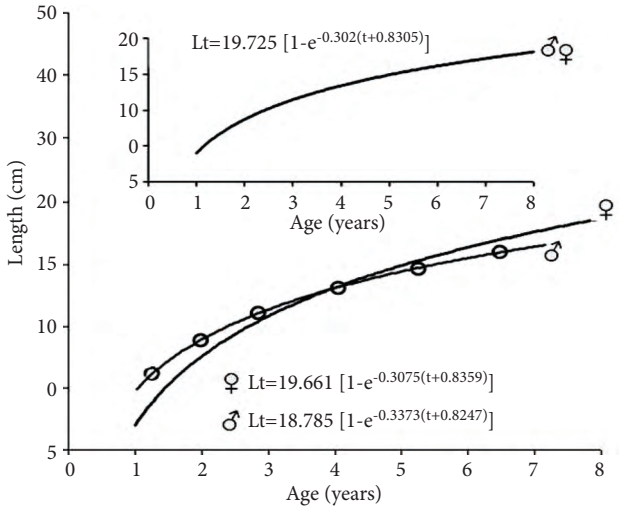

Figure 4. Length growth curves of horse mackerel males, females, and both sexes combined from Bulgarian Black Sea waters during the study period.

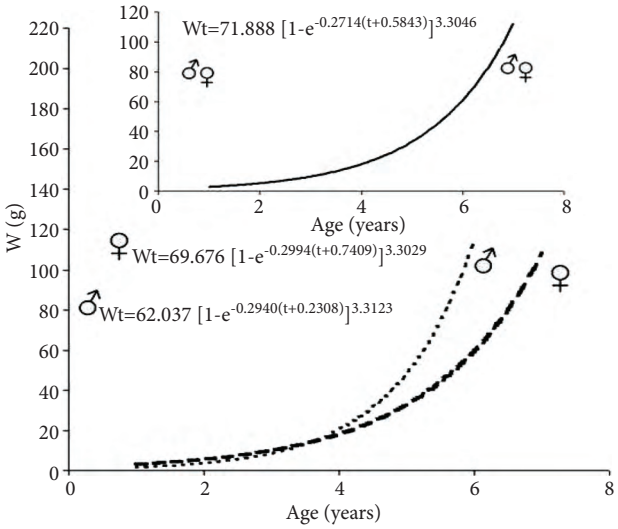

Figure 5. Weight growth curves of horse mackerel males, females, and both sexes combined from Bulgarian Black Sea waters during the study period.

Table 3. Growth parameters and von Bertalanffy growth equations for weight of females, males, and both sexes combined.

von Bertalanffy growth equations	**Sex**	W_∞	K **year**$^{-1}$	t_o	n
$W_t = 69.676[1-e^{-0.2994(t+0.7409)}]^{3.3029}$	Females	69.676	0.2994	−0.7409	3.3029
$W_t = 62.037[1-e^{-0.2940(t+0.2308)}]^{3.3123}$	Males	62.037	0.2940	−0.2308	3.3123
$W_t = 71.888[1-e^{-0.2714(t+0.5843)}]^{3.3046}$	Both sexes	71.888	0.2714	−0.5843	3.3046

investigations. Higher variability in length was observed in fish from the Turkish Black Sea coast (Şahin et al., 1997). According to Ozaydin et al. (2000), such differences may be attributed to the sampling strategy used, such as the sampling period, as well as to variations in temperature and probable differences between the trophic potential of various localities.

The horse mackerel specimens in the present study were distributed among the age groups of 0+ to 6+, while Şahin et al. (1997) reported age groups between 1+ and 6+ for the Turkish Black Sea coast. Uçkun et al. (2000) indicated that this broader age range was due to differences in sample size and sampling depth.

L_∞ values in the present study were 19.66, 18.78, and 19.60 cm for females, males, and both sexes combined, respectively. Prodanov et al. (1997) calculated an L_∞ value of 19.25 cm. Yankova and Raykov (2006) estimated the L_∞ value to be 17.55 cm. We compared the results presented by different researchers regarding population parameters and dynamics (Prodanov et al., 1997; Yankova and Raykov, 2006; present study) in Bulgarian waters, taking into consideration the fact that the Black Sea horse mackerel migrates along the Bulgarian coast (Stoyanov et al., 1963; Ivanov and Beverton, 1985; Prodanov et al., 1997; Raykov and Yankova, 2008), particularly the western small-sized *Trachurus meditteraneus ponticus* (Georgiev and Kolarov, 1962). Comparison of the growth parameters of horse mackerel in Bulgarian Black Sea waters (Table 4) showed that there were no differences (ANOVA, $F = 1.40$, $P > 0.05$).The L_∞ value given by Şahin et al. (1997) for the Turkish Black Sea Coast is 18.36 cm. In

Table 4. Comparison of the growth parameters (L_∞, K, t_o) in this study and in other studies.

Location	Sex	Age years	L_∞ (cm)	K year^{-1}	t_o
Bulgarian Black Sea[1]	male	0-5	18.78	0.3373	−0.8247
	female	0-6	19.66	0.3075	−0.8359
	total	0-6	19.60	0.2964	−0.8768
Turkish Black Sea coast[2]	total	1-6	18.357	0.4271	−0.5986
Bulgarian Black Sea[3]	total	-	19.25	0.3481	−0.5914
Bulgarian Black Sea[4]	total	1-5	19.99	0.3066	−0.4912

[1]Present study; [2]Şahin et al. (1997); [3]Prodanov et al. (1997); [4]Yankova and Raykov (2006).

the present work, growth was estimated for males and females separately. These results show that L_∞ values for females were higher than those for males. Weatherley (1972) indicated that this may be due to the faster growth rate of females and that the life span of females is longer than that of males. Raykova-Petrova and Zivkov (1987) reported that the interrelationship between the growth rate and asymptotic length is inversely proportional, as in the present investigation. Zivkov et al. (1999) identified the biological reasons for the unsuitability of growth parameters and indices in comparing growth rates, including the absence of biological significance at such high levels of L_∞, as well as growth self-regulation and compensation. The growth coefficient K = 0.2964 year^{-1} (combined samples) of horse mackerel is lower than the K reported in previous studies (Table 4). Şahin et al. (1997) determined that the growth coefficient K is a characteristic that is at least partly genetically determined and that L_∞ is phonotypical. According to Ricker (1975) this variation may be due to different stages in ontogenetic development, as well as differences in environmental conditions, length, age, sex, and gonad development. The size, quantity and quality of food, as well as water temperature are closely linked to the growth parameters of a population (Santic et al., 2002). The theoretical maximum length and weight of females were higher than those of males. The W_∞ values calculated in the present study for females and males could not be compared with those of previous studies due to the absence of available data. Prodanov et al. (1997) reported that W_∞= 73.65, which is higher than the value reported

Table 5. Comparison of the growth parameters (W_∞, K, t_o) in this study and in other studies.

Location	Sex	Age years	W_∞ (cm)	K year^{-1}	t_o	n
Bulgarian Black Sea[1]	female	0-6	69.676	0.2994	−0.7409	3.3029
	male	0-5	62.037	0.2940	−0.2308	3.3123
	total	0-6	71.888	0.2714	−0.2714	3.3046
Turkish Black Sea Coast[2]	total	1-6	56.524	0.4271	−0.5986	3.2188
Bulgarian Black Sea[3]	total	-	73.65	0.1566	−2.2641	1.7170
Bulgarian Black Sea[4]	total	1-5	66.18	0.4083	−0.2510	1.8644

[1]Present study; [2]Şahin et al. (1997); [3]Prodanov et al. (1997); [4]Yankova and Raykov (2006).

by Şahin et al. (1997) (Table 5). Our results indicate that W_{∞} =71.89, which is even higher than the value reported by Şahin et al. (1997). Yankova and Raykov (2006) established W_{∞} as 66.18 cm. Differences in growth parameters calculated from data collected at different times from the same area could possibly have been due to annual variations in mean length or weight with age (Avşar, 1995). Differences noted in growth may be attributed to variation in habitat, temperature, and possibly differences in feeding habits (Yıldırım et al., 2002). Geographic location and some environmental conditions, such as water temperature, organic matter, quality of food, date and time of capture, stomach fullness, disease, and parasite load, can also affect weight-at-age estimates (Bagenal and Tesch, 1978).

The slope (*b* value) of the length-weight relationship was similar for males (3.3123) and females (3.3029), indicating that weight increased allometrically with length. For the same species the *b* value of horse mackerel in Turkish Black Sea waters was reported to be 3.2188 by Şahin et al. (1997) and 1.7170 in Bulgarian waters by Prodanov et al. (1997) (Table 6). Comparison of the length-weight relationships observed in the present study with those of horse mackerel from other regions shows that the coefficient of the length-weight relationship differed from that reported by Prodanov et al. (1997), which was due to the time of year, the physiological state of the horse mackerel, and length range analyzed. These differences in growth between the values of n may be a result of several ecological factors, such as the characteristics of the biotope, temperature, spawning conditions, and feeding, as reported by Ricker (1975). Sinovčič reported that the coefficient of the length-weight relationship changed according to the time of year, the physiological state of the fish, and length range analyzed (Sinovčič, 2003). The allometric coefficient depends on the feeding location of the populations, sex, length, age, and gonad maturity (Martin, 1949; Ricker, 1979). Allometric growth in the present study indicates that growth in length differs from growth in weight. Changes in body shape, physiology, environmental factors, food supply, and availability, as well as growth fluctuations or stagnation influence the allometric factor (Frost, 1945; Le Green, 1951).

Conclusions

The growth parameters of horse mackerel in Bulgarian Black Sea waters do not vary significantly from those of previous reports (Prodanov et al., 1997; Yankova and Raykov, 2006; present study). The growth of horse mackerel in Bulgarian Black Sea territorial waters is positive allometric. During the first 3 years of life females and males differ in length. Males are characterized by higher growth rates than females.

Acknowledgements

Special thanks to Mr. Mladen Georgiev for his help collecting and processing the fish.

Thanks also to Mrs. Nelly Kelina for laboratory analysis. The authors wish to express their sincere thanks to the anonymous referees for their valuable contributions to the manuscript.

Table 6. Parameters of the length-weight relationship (*a*, *b*) in this study and in other studies (N: number of species; N/A: not available).

Study	Location	N	*a*	*n*	Length min-max
Present study	Bulgarian Black Sea coast	1995	0.0035	3.3046	10.5-17.00
Şahin et al. (1997)	Turkish Black Sea coast	600	0.0048	3.2188	7.4-14.5
Prodanov et al. (1997)	Bulgarian Black Sea	N/A	0.3220	1.7170	N/A
Genç et al. (1999)	Eastern Black Sea	N/A	0.0075	3.017	6.5-19

References

Avşar, D. 1995. Population parameters of sprat (Spratus sprattus phalericus RISSO) from Turkish Black Sea coast. Fisheries Research. 21: 437-453.

Ambroaz, A. 1954. Distribution and fishery of the Black Sea horse mackerel. Tr.VNIRO, V. 28: 113-125 (In Russian).

Bagenal, T. and Tesch, F.W. 1978. Age and growth. In: Methods for assessment of fish production in fresh water. I Handbook 3, T. Bagenal (Ed). Blackwell Scientific Publications, Oxford: 101-136.

Bellido, J.M., Pierce, G.J., Romero, J.L. and Millan, M. 2000. Use of frequency analysis methods estimate growth of anchovy in the Gulf of Cadis (SW Spain). Fisheries Research, 48: 107-115.

Von Bertalanffy, L. 1938. A quantitative theory or organic growth laws. Hum. Biol., 10: 181-213.

Cautis, I. and Jonescu, N. 1979. Structura populator de stavrid. In E. Pora ed. - Le Chinchard de la Mer Noire (*Trachurus mediterraneus ponticus*) Etude monographique, Deuxieme Partie: 485-508 (in Romanian).

Claramunt, R.M. and Wahl, D.H. 2000. The effects of abiotic and biotic factors in determining larval fish growth rates: a comparison across species and reservoirs. Transaction of the American Fisheries Society 129: 835-851.

Frost, W.E. 1945. The age and growth of eels (*Anguilla Anguilla)* from the Windermere catchment area. Part 2.J. Anim. Ecol., 14: 106-12.

Georgiev, Z.P. and Kolarov, 1962. On the migration and distribution of horse mackerel (*Trachurus ponticus*, Aleev) in the western part of Black Sea. Arbeiten des Zentralen Forschungsinstitutes fur Fishzught und Fisheries, Varna, II, 148-172.

Genç, Y., Zengin, M., Başar, S., Tabak, I., Ceylan, N., Çiftçi, Y., Üstündağ, C., Akbulut, B. and Şahin, T. 1999. The Research Project of Economical Marine Products. TKB, Central Fisheries Research Institute Trabzon, 157 pp.

Ivanov L.S. and Beverton, R.J.H. 1985. The fisheries resources of the Mediterranean. Part two: Black Sea. FAO Studies and Reviews, 60: 135pp.

Le Green, E.D. 1951**.** The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis).* J. Anim. Ecol, 20: 530-538.

Martin, W.R. 1949. The mechanics of environmental control of body form in fishes University of Toronto Stud. Biol., 58: 1-91.

Mikhailov, K. and Prodanov, K. 1983. Approximate assessment of the natural mortality rate of the anchovy in the Bulgarian Black Sea coast. Pross. IRR, Varna, 20: 173-182.

Özaydın, O., Bilecenoğlu, M. and Kaya, M. 2000. Age and growth of the Curled Picarel *Centracanthus cirrus* Rafinesque, 1810 (Osteichthyes: Centracanthidae) in Northern Cyprus, Eastern Mediterranean Sea. Acta Adriatica, 41: 35-42.

Pravdin, U. 1966. Manual of fish research. Nutritional Industry, Moscow, 179-191pp. (in Russian).

Prodanov, K., Mikhailov, K., Daskalov, G., Maxim, K., Chashchin, A., Arkhipov, A., Shlyakhov, V. and Ozdamar, E. 1997. General fisheries council for Mediterranean, FAO. Studies and reviews. Environmental management of fish resources in the Black Sea and their rational exploitation. Studies and reviews, 68: 73-81.

Raykov, V and Yankova, M. 2008. Growth dynamics and mortality estimation of the Horse Mackerel (*Trachurus mediterraneus ponticus*, Aleev) migrating along the Bulgarian Black Sea Coast. Proceedings of first Biannual Scientific Conference "Black Sea Ecosystem and Beyond" 8-10 May 2005, Istanbul, 765-778.

Raykova-Petrova, G. and Zivkov, M. 1987. Biological meaning and practical use of the parameters from Bertalanffy equation in fish. Contemporary achievements of the Bulgarian zoology, Institute of Zoology - BAS, 105 (in Bulgarian).

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish Res. Board Can., 191: 382.

Ricker, W.E. 1979. Growth rates and models. In W.S. Hoar, D.J. Randal & J.R. Brett (Editors). Fish physiology, 8. Academic Press, London, 786.

Santic, M., Jardas, I. and Pallaoro, A. 2002. Age, growth and mortality rate of horse mackerel *Trachurus trachurus* (L.) living in the eastern Adriatic, Vol. 104: 165-173.

Şahin, T., Genç, Y. and Okur , H. 1997. Investigation of the growth and reproduction of horse mackerel (*Trachurus mediterraneus ponticus* Aleev) population in Turkish Black Sea Coast. Turkish Journal of Zoology, 21: 321-328 (in Turkish).

Sinovčič, G. 2003. The length-weight relationship of anchovy, *Engraulis engrasicolus* (L.), in the eastern Adriatic Sea. Acta Adriatica. 44: 181.

Stoyanov, St., Georgiev, Z., Ivanov, L., Hristov, D., Kolarov, P., Aleksandrova, K. and Karapetkova, M. 1963. Fishes in Black Sea. State Publishing house, Varna, pp. 101.

Sogard, S.M. 1994. Use of suboptimal foraging habitats by fishes: consequences to growth and survival. In Theory and Application in Fish Feeding Ecology (Stouder, D.J., Fresh, K.L. & Feller, R.J., eds.) , Columbia, SC: University of South Carolina Press, 103-131.

Uçkun, D., Toğulga, M. and Taşakavak, E. 2000. A preliminary study on the growth of the Common hake (*Merluccius merluccius L.*, 1978) in Izmir Bay, Aegean Sea. Acta Adriatica, 41: 25-34.

Valkanov, Al., Marinov, H., Danov, H. and Vladev, P. 1978. Black Sea (collection) State Publishing house, Varna, pp. 13.

Weatherley, A.H. 1972**.** Growth and ecology of fish ecology of fish populations. Academic Press, London, pp. 293.

Zivkov, M., Trichkova, T. and Raikova-Petrova, G. 1999. Biological reasons for unsuitability of growth parameters and indexes for comparing fish growth. Environmental Biology of Fishes, 54: 67-76.

Yankova, M. and Raykov, V. 2006. Approximate assessment of the horse mackerel natural mortality rate, *Trachurus mediterraneus ponticus,* Aleev in the Bulgarian Black Sea territorial waters. Secretary marine I.N.C.D.M. 36, 341-348.

Yıldırım, A., Erdoğan, O. and Türkmen, M. 2002. On the age, growth and reproduction of the Barbel, *Barbus plebejus* (Steindachner, 1987) in the Oltu Stream of Çoruh River (Artvin-Turkey). Turk. J. Zool. 25: 163-168.