www.trjfas.org
ISSN 1303-2712
Turkish Journal of Fisheries and Aquatic Sciences 11: 641-648 (2011) DOI: 10.4194/1303-2712-v11_4_19

The Growth Characteristics of Sand Smelt (*Atherina boyeri*, Risso 1810) in Lake İznik (Türkiye)

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Received 27 August 2010
Accepted 21.July 2011

Abstract

In this study, growth properties of sand smelt (*Atherina boyeri*, Risso 1810) in İznik Lake were determined. Total catched 237 sand smelt fish in January-December 2006 were 28.3% male and 71.7% female. Female male ratio was 2.5:1. Fork length between 2-10.6 cm, weight 0.06-10.5 g, ages I-IV were changed and 20.7% fish were I. age were determined. Differentiation between average lenght frequency of groups wasn't statistically significant (P>0.05) in I. age group. The data were obtained LogW=-2.09593-2.9819 Log L and $W=0.008018\ L^{2.9819}$ (r=0.993) for male fish, Log W=-2.12773-3.0508 Log L and $W=0.007452\ L^{3.0508}$ (r=0.996) for female fish and Log W=-2.13401-3.0511 Log L and $W=0.007345\ L^{3.0511}$ (r=0.994) for male and female fish. Total, natural and fishery mortality rates respectively were M=0.666 y^{-1}, F= 0.1591 y^{-1} and E=0.193 y^{-1}. The highest relative length and weight growth were shown male and female between I-II ages. For female and male fish W_∞=32.3, K=0.23794, t_o = -0.1994, b= 3.0511 and Von Bertalanffy weight growth equation $W_{(t)}=32.3*(1-e^{-0.23794(t+0.1994)})^{3.0511}$ were determined. Condition factor were determined K=0.780 for male and K=0.822 for female and differentiation between sexual groups for II to III statistically were not significant (P>0.05).

Keywords: Growth, mortality rate, von Bertalanffy, condition factor.

İznik Gölü'ndeki Gümüş Balığı (Atherina boyeri, Risso 1810)'nın Büyüme Özellikleri

Özet

Bu çalışmada İznik Gölü'ndeki gümüş balıklarının (*Atherina* boyeri, Risso 1810) büyüme özellikleri incelenmiştir. Ocak-Aralık 2006 tarihleri arasında elde edilen toplam 237 adet gümüş balığının %28,3'ü erkek, %71,7'si dişi bireylerden oluşmuştur. Dişi erkek oranı 2,5:1'dir. Çatal boyları 2-10,6 cm, ağırlıkları 0,06-10,5 g ve yaşları I-IV arasında değişen bireylerin %20,7'sinin I yaşında olduğu tespit edilmiştir. Ortalama boy grupları arasındaki fark I yaş grubunda önemsiz (P>0,05) bulunmuştur. Erkek bireylerde Log W = -2,09593-2,9819 Log L ve $W = 0,008018\ L^{2,9819}$ (r=0,993), dişi bireylerde Log W=-2,12773-3,0508 Log L ve $W=0,007452L^{3,0508}$ (r=0,996), dişi+erkek bireylerde Log W=-2,13401-3,0511 Log L ve $W=0,007345L^{3,0511}$ (r=0,994) değerleri elde edilmiştir. Total, doğal ve balıkçı ölümü değerleri sırasıyla M=0,666 $yıl^{-1}$, F=0,1591 $yıl^{-1}$ ve E=0,193 $yıl^{-1}$ olarak belirlenmiştir. En yüksek oransal boyca büyüme ve ağırlık artışı erkek ve dişilerde I-II. yaş arasında gözlenmiştir. Dişi+erkek bireyler için W_∞=32,3, K=0,23794, t_o = -0,1994, b= 3,0511 ve von Bertalanffy ağırlıkça büyüme denklemi $W_{(t)}=32,3*(1-e^{-0,23794(t+0,1994)})^{3,0511}$ olarak belirlenmiştir. Kondisyon faktörü erkeklerde K=0,780, dişilerde K=0,822 olarak belirlenmiş olup, eşey grupları arasındaki fark istatistiksel olarak II. ve III. yaşlarda önemsiz (P>0,05) bulunmuştur.

Anahtar Kelimeler: Büyüme, ölüm oranı, von Bertalanffy, kondisyon faktörü.

Introduction

Sand smelt (*Atherina boyeri*) (Figure 1) is a member of Atherinidae family which have large adaptation talent and shows regional differentiation for morphological and biological characteristic. Therefore, it was supposed to be great numbers of Atherinidae species actually generally accepted that is only one species, *A. boyeri*, and for this variety reason is complex polymorphism of sand smelt in the Mediterranean basin (Altun, 1986). It was determined two species addition to sand smelt in the Mediterranean basin. The first species is *A. lagunae* which lives in lagoonal area and other species has freckles, was named *A. punctata,* lives in the sea (Trabelsi *et al*., 2002a, 2002b). Sand smelt exist in inland waters and ambient seas of Türkiye (Altun, 1986; 1991; 1999; Buhan, 1998; Geldiay and Balık,

Figure 1. Sand smelt (*Atherina boyeri*) (The photo was taken by Yegen)

1996; Kuru *et al*., 2001; Özuluğ *et al*., 2005; Sezen, 2005).

The great number of study were made on biology, ecology, population structure of sand smelt etc. in the distributed areas species of Atherinidae genus in the world (Rosecchi and Crivelli, 1995; Bardın and Pont, 2002; Tomasini *et al*., 1996; Tomasini and Laugier, 2002; Moreno *et al*., 2005).

Study Area

İznik Lake is in southeast of Marmara region, 40°23′–40°30′ N- 29°20′–29°42′ E, in Bursa province. İt is in the tectonic depression which in between Gemlik gulf and Geyve basin. East-west direction length of Lake is about 32 km and North-south is 12 km and its figure like an elips. Lake surface is 313 km^2 and depth 80 m. The Lake is surrounded by medium height mountains (Numann, 1958; Yarar and Magnin, 1997; Aktan and Aykulu, 2001; Kubanç and Kılınçarslan, 2001).

Materials and Methods

Sand smelt was used the study which catched montly with beach seine (codend mesh size 4 mm and wing 5 mm; codend length 5 m and wing 10 m) in was determined primarily station from January to December 2006.

The fork length of catched fish were measured using a measuring board (L, cm; ±1 mm precision) and weight were weighed (W, ±0.01 g precision with -AND GX-4000, Japan-scala). Gonads of fish were analyzed for determining sex and sexual maturation rate.

Age determination was made on the scala according to Lagler (1966) and Nikolsky (1963) and computation with using length range. Length-weight correlation was determined using Log W = Log a + b Log L and $W = a\ L^b$ equations denoted by Le Cren (1951). Relative increase on length and weight value were determined using below equation on the ages groups.

$$OL = \frac{L_{(t)} * L_{(t+1)}}{L_{(t+1)}}$$

$$OW = \frac{W_{(t)} * W_{(t+1)}}{W_{(t+1)}}$$

Age-length and age-weight correlations were determined using Von Bertalanffy's length growth [$(L_{(t)}=L_\infty*(1-e^{-K(t-t_0)})$] (Buhan, 1998) and weight growth ($W_{(t)}=W_\infty*(1-e^{-K(t-to)})^b$) equations and condition factors were computationed using Ricker's isometric growth equation ($KF=(W/L^3)*100$) (Erkoyuncu, 1995).

Pauly's (1980) empirical equation (Ln M= -0.0152-0.279*ln L_∞+0.6543*ln K+0.463*ln T) was used for determining natural mortality coefficient. In this equation, L_∞ and K is Von Bertalanffy growth parameters, T is average water temperature in the Lake. L_∞ shown maximum asymptotic length (cm) and K, brody growth coefficient and T, annual average water surface temperature (°C).

Linearised annual fisheries data were used for determining annual average total mortality, annual total average mortality rate (Z) was approved as slope of aslope b (Sparre and Venema, 1998).

Z= -b was used for determining total mortality rate. Fisheries mortality rate (F) was determined by natural mortality (M) subtraction from calculated annual total mortality rate (F=Z-M) (Buhan, 1998).

Results

Catched 237 sand smelt for study consisted 28.3% (67 number) were male and 71.7% (170 number) were female. Female male ratio was 2.5:1. Fish length changed between 2-10.6 cm, weight 0.06-10.5 g and age I-IV. It was determined that 20.7% of total fish were I. aged, 24.5% II. aged, 22.8% III. aged, and 32.1% IV aged (Table 1, Figure 2). When examined individual range respect to age group, IV. aged group was the biggest group consisted with 76 individual and 32.1% ratio, and I. aged group was consisted fewest individual with 49 fish and 20.7% ratio were determined.

Length-Weight Correlation

The highest average length data was obtained as

Table 1. Age and sex composition of *A. boyeri* population

Age	♂		♀		♂+♀	
groups	N	N%	N	N%	N	N%
I	24	10.1	25	10.5	49	20.7
II	24	10.1	34	14.3	58	24.5
III	16	6.8	38	16.0	54	22.8
IV	3	1.3	73	30.8	76	32.1
∑	67	28.3	170	71.7	237	100

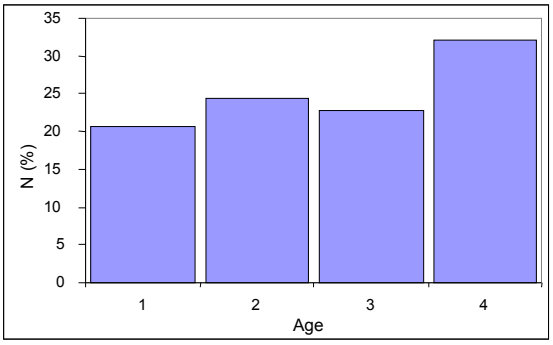

Figure 2. Age composition of *A. boyeri* population (Male+Female)

9.9±0.042 cm for IV aged group female+male and the lowest data as 3.6±0.208 cm for I aged group female. The highest weight value was determined as 8.3±0.117 g for IV aged female, and the lowest as 0.5±0.048 g for I aged female+male (Table 2). Differentiation between average length gorups were determined significant (P<0.05) for II, III, and IV aged groups and was not sigificant (P>0.05) for I aged group (Figure 3 and 4).

Length Growth

Length growth data has been computationed according to sex offered on Table 3. As is seen from the table the highest rational length growth data were obtained from male+female between I and II aged sand smelt fish. Rational length growth with inversely correlated was decreased other age groups.

L_∞ and K values for sex groups each other were determined very close (Table 4). Therefore, shared growth aslope was drawn because of belong to very close data on computationed age-length data for sex on growth aslope (Figure 5).

Differentiation between measuring length data for both sex group and computationed length data using by Von Bertalanffy's growth equation were statistically significant (P<0.05) for II, III and IV aged groups and not significant (P>0.05) for I aged group.

Weight Growth

The highest rational weight growth data were obtained from male and female between I and II aged groups of sand smelt fish. Rational weight growth was decreased for other age groups correlated with increase age (Table 5, Figure 6). In addition, differentiation between measuring weight data for both sex groups and computationed weight data using by Von Bertalanffy's growth equation were statistically significant (P<0.05) for II aged group and not significant (P>0.05) for I, III, and IV aged groups (Table 5).

Weigth growth data were shown Table 6 which were obtained for sand smelt population by using Von Bertalanffy. Growth performance of sand smelt in İznik Lake was computationed as Q=4.058 by using Q=ln 0.23794 + 2 * ln 15.6 equation.

Condition Factor

An increasing of condition factor in sand smelt population was determined correlated with increase of fish age for both male and female (Table 7). When condition factors analyzed for sex groups, generally obtained data from male were lower from female. Differentiation between condition factors of sex groups statistically not significant (P>0.05) were determined for II and III aged groups and siginificant (P<0.05) for I and IV aged groups.

Mortality Rate

Natural mortality rate was computationed by using Pauly's (1980) empirical equation In this computation, Von Bertalanffy's growth parameters K=0.23794; L_∞=15.6 cm and average water temperature of lake T=17.1°C data were used. By using those data was obtained from

lnM=-0.0152-0.279*ln15.6+0.6543*ln0.23794+0.463 *ln 17.1 equation;

Table 2. Length and weight data according to age groups of *A. boyeri* population

Age groups	♂		♀		♂+♀	
	L±SE	W±SE	L±SE	W±SE	L±SE	W±SE
I	4.2±0.188	0.6±0.071	3.6±0.208	0.5±0.059	3.9±0.146	0.5±0.048
II	6.6±0.133	2.3±0.138	6.3±0.125	2.1±0.120	6.4±0.093	2.2±0.090
III	8.1±0.077	4.1±0.128	8.3±0.096	4.8±0.181	8.2±0.072	4.6±0.140
IV	9.8±0.219	6.9±0.448	9.9±0.042	8.3±0.117	9.9±0.042	8.2±0.118

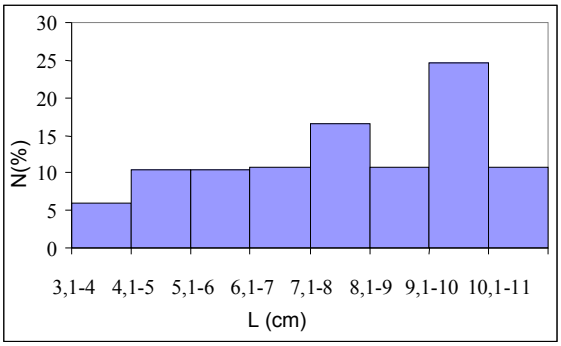

Figure 3. Length composition of *A. boyeri* population.

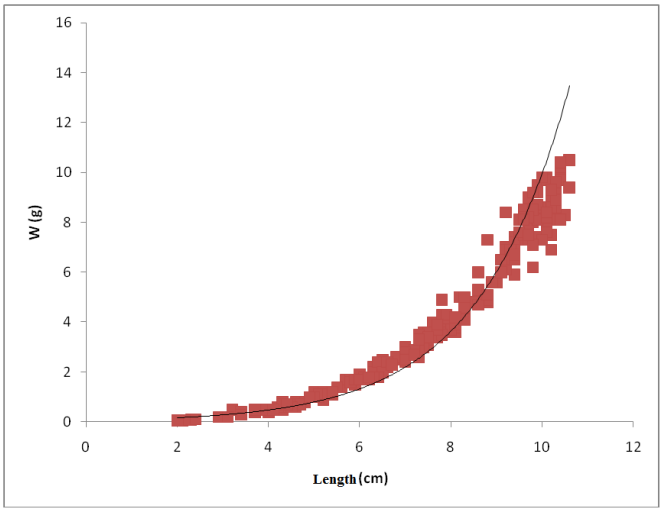

Figure 4. Length-weight correlation of sand smelt population (male+female)

Table 3. Rational length growth between age gorups of sand smelt

Age Groups	♂			♀			♂+♀		
	L	ΔL	RL	L	ΔL	RL	L	ΔL	RL
I	4.2			3.6			3.9		
		2.4	42.9		2.7	32.5		2.5	39.1
II	6.6			6.3			6.4		
		1.5	26.8		2.0	27.4		2.2	34.4
III	8.1			8.3			8.2		
		1.7	30.4		1.6	21.9		1.7	26.6
IV	9.8			9.9			9.9		

Table 4. Growth parameters and von Bertalanffy length growth equation

	L_∞	K	t_o	Von Bertalanffy length growth equation
♂+♀	15.6	0.23794	-0.1994	$L_{(t)}=15.6*(1-e^{-0.23794(t*+0.1994)})$

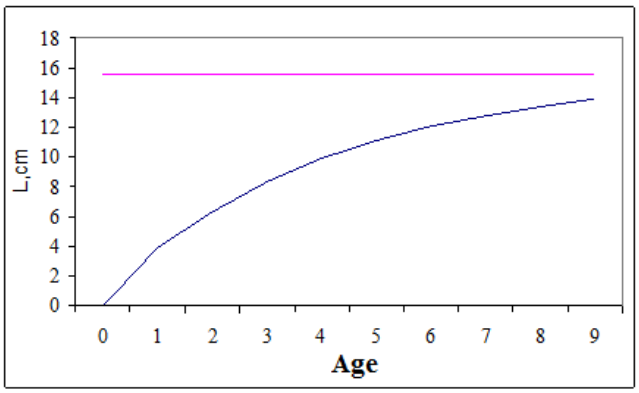

Figure 5. Length growth aslope of sand smelt.

Table 5. Rational weight growth between age gorups of sand smelt

Age	♂			♀			♂+♀		
Groups	W	ΔW	RW	W	ΔW	RW	W	ΔW	RW
I	0.6			0.5			0.5		
		1.7	251		1.6	380.6		1.7	301.5
II	2.3			2.1			2.2		
		1.8	78.7		2.7	131.1		2.4	112.3
III	4.1			4.8			4.6		
		2.8	69.8		3.5	72.3		4.4	79.4
IV	6.9			8.3			8.2		

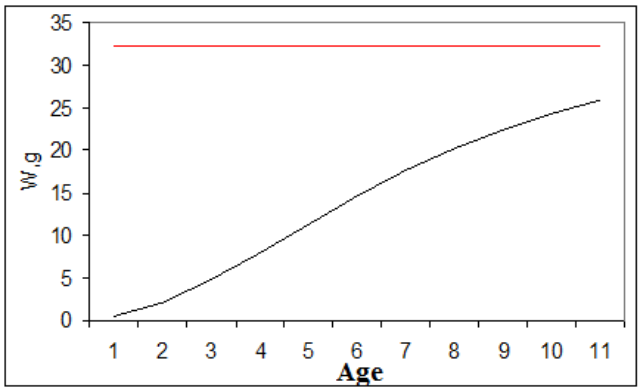

Figure 6. Weight growth aslope of sand smelt population.

Table 6. The obtained data by using Von Bertalanffy's weight growth equation of sand smelt

	W_∞	K	t_o	b	Von Bertalanffy's weigth growth equation
♂+♀	32.3	0.23794	-0.1994	3.0511	$W_{(t)}=32.3*(1-e^{-0.23794(t+0.1994)})^{3.0511}$

Table 7. Average condition factor correlated with age groups of sand smelt

Age	♂	♀	♂+♀
groups	KF±SH	KF±SH	KF±SH
I	0.788±0.017	0.8±0.036	0.794±0.141
II	0.78±0.012	0.811±0.013	0.798±0.068
III	0.762±0.014	0.825±0.014	0.807±0.081
IV	0.791±0.02	0.853±0.009	0.851±0.079
Mean	0.780±0.016	0.822±0.018	0.813±0.092

lnM=-0.406598

M=0.666 were determined. This natural mortality rate was include individuals joined to population.

Also mentioned as total mortality rate Z= -b value was computationed as 0.8251 by using regression equation. As a result, total mortality rate for bigger than 3 cm sand smelt individuals were determined as Z=0.8251

Fishery mortality was determined as F=0.1591 by using Z=0.8251 and M=0.666 values with F=Z-M equation. Surviving rate was determined as S=43.8% with $S=e^{-0.8251}*100$ equation.

Mentioning of mortality rate as percentage for fishery mortality by using C= (0.1591/0.8251) * (100-43.8) equation as C=10.8%, for natural mortality as D=45.3% were determined. Total mortality rate was determined as 56.1% (45.3+10.8) accumulation with fishery and natural mortality rate.

Discussion

Fork length of catched sand smelt in İznik Lake were ranged between 2.0-10.6 cm. In a study, which was made by Özeren (2004), fork length of sand smelt were determined as 0.6-10.9 cm and by 58.6% ratio widespread length group as 5.6-10.9 cm in same lake. Also in other study (Gaygusuz, 2006) declared that length of sand smelt ranged between 2.7-11.9 cm for female and by 28.7% ratio widespread length group as 10.0-10.9 was determined. Total length of sand smelt was declared ranged between 3.5-11 cm for Küçükçekmece Lake by Altun (1986). Sezen (2005) was declared total length of sand smelt ranged between 2.4-10.3 cm and by 18.5% ratio intensity 5 cm length group for İzmir Homa Lagoon. Fork length for Eğirdir Lake 2.47-9.41 cm by Küçük *et al*. (2006); total length data for Mala Neretva as 3.1-11.6 cm by Bartulovic at al. (2004); total length for Vistonis estuarine system as 1.3-10.5 cm by Koutrakis at al. (2004); the highest length data for 3 aged female as 10.3 cm on Mesolongi and Etolikon lagoon by Leonardos and Sinis (2000) and for Mar Menor lagoon as 3.9-9.4 cm by Soler *et al*. (2003), were declared. If we analyzed the above data obtained in other studies is similar to obtained us for İznik Lake. In this case was seen that regional and spatial changes were not efficient on length frequency distribution.

Despite as 0.06-10.5 g weight data were obtained by us for sand smelt, Özeren (2004) was obtained as 0.03-7.37 g for sand smelt in same lake. Also were determined data as 0.10-10.36 g by Gaygusuz (2006) in İznik Lake. İn Homa lagoon same data were obtained as 0.08-8.11 g by Sezen (2005), and in Eğirdir Lake as 0.4-6.7 g by Küçük *et al*. (2006). Rational weight increasing decreases with age increase as is rational length growth increase. Generally, rational growth increase was computationed for all individual the highest as 2.80 g for 0-I aged groups, the lowest as 0.75 g for III-IV aged groups by Özeren (2004). Also in our study, the highest rational weight increase was determined as 4.4 g in III-IV aged groups for male + female and the lowest increase as 1.6 g in I-II aged groups for female individual. Our data for obtained in İznik Lake were shown same parallelism with obtained by Gaygusuz (2006) but not parallelism other studies because of shown rational the highest. Those result were give rise to thought us dietary features which changed with geographically and regional differentiations were efficient on sand smelt weight.

In our study, ages of cacthed fish were changed between I-IV and IV aged group was predominant with 32.1% ratio were determined. Age distribution were determined as between 0-IV and with 38.6% ratio 0 age group was predominant by Özeren (2004), as between 0-III by Altun (1986, 1991), as between 0+-III and with 50.3% ratio I aged group was predominant by Sezen (2005), as between 0+-II+ and with 53.95% ratio I+ aged group was predominant by Küçük *et al*. (2006), as between 0+-III+ and 0+ and I+ aged groups were predominant by Leonardos and Sinis (2000), as between I+-III+ and with 56.49% ratio I+ aged group was predominant by Soler *et al*. (2003), as between I-IV and with 90% ratio I and II aged groups were predominant by Bartulovic *et al*. (2004), as between 0-IV by Koutrakis *et al*. (2004). It was propability a lot of reason for draw the attention age distribution differantiations. Especially, it will not deceptive correlate with caused differantions on obtained data from studies in İznik Lake with period, study conditions, differentiation sampling methodology and changed in population.

Obtained data in our study for the lowest average condition factor for III aged male was 0.762±0.014 and the highest IV aged female was 0.853±0.009. Those data were obtained as the lowest for 0 age group as 0.41±0.01 and the highest for IV aged group as 0.75±0.01 by Özeren (2004). Gaygusuz (2006) was computationed condition factor according to ages and months and was determined the lowest as 0.352±0.087 for 0 aged group and the highest as 0.695±0.051 for IV aged group individuals and the highest average data according to months as 0.714 for May for female individuals, and the lowest as 0.506 for September. Küçük *et al*. (2006) were determined condition factors for sand smelt individual in Eğirdir Lake for 0+, I+ and II aged groups as 2.39±0.154, 0.76±0.008 and 0.77±0.007 respectively. Koutrakis *et al*. (2004) were expressed condition factors were changed between 0.53-0.63 from February 1990 to Auğust 1990. Obtained data by us for condition factor was lower than obtained from Küçük *et al*. (2006) in Eğirdir Lake for 0+ aged group, whereas were shown parallelism other age groups. In generally our data were higher than obtained in other studies. The data were obtained in İznik Lake by us can acceptable as an indicatively for sand smelt have beter conditions for feeding in there.

If seen changes in a short time ongoing for sand

smelt population, we think sustainability of population will endangered.

L_∞ was determined as 15.6 cm for all individuals by us. This parameter was obtained as 11.53 cm by Altun (1986), for all individuals as 13.45 cm by Sezen (2005), as 12.88 cm by Gaygusuz (2006), for all individuals as 11.579 cm by Leonardos and Sinis (2000), for all individuals as 13.503 cm by Bartulovic *et al*. (2004) and for all individuals as 11.697 cm by Koutrakis *et al*. (2004). Computationed data by us for L_∞ was the highest than obtained in other studies. With measurements obtained data through the calculation of these values to be different was normal.

Total mortality rate as Z=0.8251, fishery mortality rate as F=0.1591 and mortality rate of sand smelt as 56.1% were determined in İznik Lake. 56.1% rate were consisted 45.3% natural mortality, and 10.8% fishery mortality. Total mortality were mentioned as Z= 0.93/year by Leonardos and Sinis (2000), as 1.81/year by Bartulovic *et al*. (2004), for all individuals as Z=1.29/year, for male as Z=1.54/year and female Z=0.97/year by Koutrakis *et al*. (2004). Also natural mortality rate were determined as M=0.41/year by Leonardos and Sinis (2000), as M= 0.90/year Bartulovic *et al*. (2004), for all individuals as M=0.95/year, for male as M=0.51/year, for male as M=0.76/year and fishery mortality for all individuals as F= 0.34/year by Koutrakis *et al*. (2004). Differentiation between obtained data by us and other studies were could originated from differentiation study locality.

In our study W_∞ data was computationed as 32.3 g. This data was determined as 8.3 g by Sezen (2005). The data related to W_∞ were not found in other study.

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