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Length Based Growth Estimates and Reproduction Biology of Whiting, *Merlangius merlangus euxinus* (Nordman, 1840) in the Southeast Black Sea

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Abstract

Growth pattern and reproductive biology of whiting, *Merlangius merlangus euxinus* were studied in southeast Black Sea between April 2011 and March 2012. The seasonal von Bertalanffy growth equation parameters, computed from monthly length frequency distributions, were estimated as L_∞ = 18.95 cm TL, K = 0.900 year^{-1} for males and as L_∞ = 20.29 cm TL, K = 0.805 year^{-1} for females. Seasonal oscillation of growth for males (C = 0.510) were stronger than females (C = 0.197), and the time of the slowest growth period corresponded to May (WP = 0.358) in males and January (WP = 0.040) in females. Fecundity ranged between 11659 and 354204 eggs (mean 70,919±11,659 eggs) and fecundity - total length relationship was significantly different from zero (P<0.0001). The growth of gonad from stage 1 to stage 4 appeared throughout the year and recently spent gonad was also observed only in August, December and January for both sexes. Spawning continues throughout the year with intensive spawning occurred at last three times in a year; at the end of the summer, in mid-autumn and in early winter. The size at sexual maturity was estimated as 14.6 cm TL for females and 13.9 cm for males. The protection of whiting breeding and for a sustainable whiting fishery with bottom gill nets, the smallest capture size should be applied as 15 cm TL.

Keywords: Whiting, *Merlangius merlangus euxinus*, seasonal growth, reproduction cycle, Black Sea, ELEFAN.

Güneydoğu Karadeniz'de Mezgit Balığının, *Merlangius merlangus euxinus* (Nordman, 1840), Boya Dayalı Büyüme Tahmini ve Üreme Biyolojisi

Özet

Mezgit balığının, *Merlangius merlangus euxinus*, büyüme şekli ve üreme biyolojisi güneydoğu Karadeniz'de Nisan 2011 ve Mart 2012 tarihleri arasında çalışılmıştır. Aylık boy frekans dağılımından hesaplanan mevsimsel von Bertalanffy büyüme denklemi parametreleri erkekler için L_∞ = 18,95 cm TL, K = 0,900 yıl^{-1}, dişiler için L_∞ = 20,29 cm TL, K = 0,805 yıl^{-1} olarak hesaplanmıştır. Erkeklerin (C = 0,510) büyümesindeki mevsimsel salınım dişilerden (C = 0,197) daha güçlü olup, büyümenin en yavaş olduğu dönem, erkeklerde Mayıs ayına (WP = 0,358) dişilerde ise Ocak ayına (WP = 0,040) karşılık gelmiştir. Yumurta verimi 11659 ve 354204 arasında değişmiş (ortalama 70.919±11.659 yumurta), yumurta verimiyle toplam boy arasındaki ilişki istatistiksel olarak sıfırdan farklı bulunmuştur (P<0,0001). Gonadlardaki büyüme 1. safhadan 4. safhaya kadar yıl boyunca devam etmiş, her iki cinsiyet için henüz boşalmış gonalar Ağustos, Aralık ve Ocak aylarında tespit edilmiştir. Yumurtlama yıl boyunca devam etmiş, yoğun şekilde yumurtlama ise yaz sonunda, sonbahar ortasında ve kış başında olmak üzere yılda en az üç kez gerçekleşmiştir. Cinsi olgunluk boyu dişiler için 14,6 cm TL, erkekler için ise 19,9 cm olarak hesaplanmıştır. Üreyen balığın korunması ve mezgit dip uzatma solungaç ağlarıyla sürdürülebilir bir mezgit balıkçılığı için asgari yakalama boyunun 15 cm TL olarak uygulanması önerilmiştir.

Anahtar Kelimeler: Mezgit, *Merlangius merlangus euxinus*, mevsimsel büyüme, üreme sirkülasyonu, Karadeniz, ELEFAN.

Introduction

Whiting, *Merlangius merlangus* is distributed in the northeast Atlantic: southeastern Barents Sea and Iceland to Portugal, also in the Black Sea, Aegean Sea, Adriatic Sea and adjacent areas and also rare in the northwestern Mediterranean (Froese and Pauly, 2012). The distribution of whiting in the Mediterranean basin often gives rise to the debate about the possible distinction of the subspecies: *M. merlangus merlangus* and *M. merlangus euxinus*. Although, whiting population in the Black Sea is reported as *Merlangius merlangus euxinus* (Nordman, 1840), *Gadus merlangus euxinus* Nordman, 1840 and *Odontogadus merlangus euxinus* (Svetovidov, 1935) in literature (Prodanov, 1980; Ismen, 1995a,b; Samsun and Erkoyuncu, 1998; Çiloğlu *et al.,* 2001; Ismen, 2002), it was reported as *Merlangius merlangus* for Black Sea, Sea of Marmara and Aegean Sea by Fricke *et al*. (2007) and in FishBase 2012 (Froese and Pauly, 2012). Fricke *et al*. (2007) have also mentioned that whiting' Black Sea to Aegean Sea populations is isolated from other populations. Furthermore, Milić and Kraljević (2011) have recently supported that population of whiting from Black Sea is subspecies *M. m. euxinus*.

Whiting is one of the most important commercial demersal fish species in the Black Sea coast of Turkey and mainly fished by bottom trawl during autumn and winter and by gillnets throughout the year. According to the statistics of the TUIK (Turkey Statistical Institute), the average annual catch of whiting for last decades was 10,231±661.2 tons (between 8,000-13,558 tons), which constitute about 2.4±0.2% (between 1.8-3.4%) of the total marine fisheries production of Turkey (TUIK, 2001-2010).

Otoliths based growth estimation and reproduction biology of whiting, *M. m. euxinus* were investigated especially in the Turkish Black Sea coast (Uysal, 1994; Ismen, 1995a, 1995b; 2002; Şahin and Akbulut, 1997; Samsun and Erkoyuncu, 1998; Çiloğlu *et al.,* 2001; Samsun, 2005, 2010), in the Bulgarian Black Sea coast (Prodanov, 1980; Bradova and Prodanov, 2003) and in the Romanian Black Sea coast (Maximov *et al*., 2007).

Length frequency data analyses (LFDA) can also be used to estimate growth parameters of fish populations and others like mortality rates (Pauly, 1990; Pauly *et al*., 1995; García and Duarte, 2006). A modified von Bertalanffy growth model has been developed to incorporate such a seasonal growth pattern (Somers, 1988). A seasonal growth pattern has recently been reported for two fish species, garfish, *Belone belone* (Kalayci and Yeşilçiçek, 2012) and anchovy, *Engraulis encrasicolus* (Bilgin *et al.,* 2012) in the Black Sea. However, there is no detailed information on the seasonal growth rate of whiting in the Black Sea. Therefore, the aim of this study was to estimate the seasonal von Bertalanffy growth parameters using length frequency data for each sex and reproduction biology (e.g. gonad development, spawning period, size at sexual maturity, fecundity) of whiting in the southern Black Sea.

Materials and Methods

Monthly samplings were conducted between April 2011 and March 2012 in the Rize coast, in the southern Black Sea. Individuals were captured with commercial whiting fishermen's whiting bottom gill nets 17, 18, 20 mm bar mesh sizes between 55 and 70 m depth. Bottom structure included mussels, gravel and stony beds and bare sandy habitats.

The total length (TL) of each whiting was measured with a sensitivity of 1 mm. Specimens and gonad weight were weighed (wet weight) on a balance with a sensitivity of 0.001 g.

Least squares regression analysis with MS Excel software was used to calculate the weight-length relationship parameters. The weight-length relationship was estimated using log transformed weight and length data as:

$$\text{Log}(W) = a + b \times \log(TL),$$

where W is the body weight (g), TL is the total length (cm), *a* is the intercept, and *b* is the slope of the regression line.

The standard von Bertalanffy growth (VBG) equation $L_t = L_\infty [1-e^{-K(t-to)}]$ predicts length as a function of age and is used when growth has a non-seasonal pattern. Seasonal growth was described using the Somers's (1988) version of the VBG equation:

$$L_t = L_\infty \left[1 - e^{\left[-K(t-t_o) - \left(\frac{CK}{2\pi}\right)\sin 2\pi(t-t_S) + \left(\frac{CK}{2\pi}\right)\sin 2\pi(t_o - t_S) \right]} \right]$$

where, L_t is length at age t, L_∞ is the asymptotic length to which the whiting grow, *K* is the growth-rate parameter, t_0 is the nominal age at which the length is zero, *C* is the relative amplitude ($0 \leq C \leq 1$) of the seasonal oscillations, t_S is the phase of the seasonal oscillations ($-0.5 \leq ts \leq 0.5$) denoting the time between 0 and the start of the convex segment of the first sinusoidal oscillation.

The period of lowest growth rate, known as the winter point (*WP*), was calculated as: $WP = t_S + 0.5$.

Seasonal and non-seasonal VBG curves were fitted to the length distributions after first displaying a range of values of *K* and L_∞ and decreasing iteratively the range to maximize the goodness of fit (Rn) of the VBG curves to the data. Rn values were calculated as:

$$Rn = \frac{10^{\frac{ESP}{ASP}}}{10}$$

where, ASP is the available sum of peaks, computed by adding the best values of the available peaks, and ESP is the explained sum of peaks, computed by summing all the peaks and troughs hit by the VBG curve.

To estimate growth parameters from length data, monthly length frequency distributions were constructed using 0.5 cm TL size class intervals. The VBG parameters of the seasonal and non-seasonal versions were estimated using the Electronic Length Frequency Analysis (ELEFAN) (Pauly, 1987) with the computer package Length Frequency Distribution Analysis (LFDA; Kirkwood *et al.,* 2001). These estimations were conducted for females and males separately. Note that the female fish in the largest size (28.1, 28.3, 28.6, 30.7 cm TL) sampled in May 2011 were not used in the growth analysis because these individuals caused lower Rn value and lots of growth curves between the truncated size structures of female. So, only monthly distributions for which up to 23 cm size classes in females were available were used in the growth analysis.

Growth performance comparisons were made using the growth performance index (Φ') which is preferred rather than using L_∞ and K individually (Pauly and Munro, 1984) and is computed as:

$$\Phi' = \log(K) + 2\log(L_\infty).$$

The maturity stages were determined within five categories, based on morphological characteristics of the ovaries and testes, modified by Gerritsen *et al*., (2003): stage 1: virgin, stage 2: developing virgin, stage 3: mature, stage 4: ripe or running, and stage 5: recently spent.

The spawning period was graphically determined for both sexes by the monthly variation of mean values of the gonadosomatic index (GSI) as:

$$\text{GSI} = \frac{Wg}{W} \times 100$$

where, Wg = gonad weight (g), W = total weight (g).

A total of 34 mature ovaries with stage 3 and 4 (ripe not running) were used for fecundity estimation. The mature ovaries were cut longitudinally and fixed separately in Gilson's fluid. The ovaries were regularly vigorously shaken about 30 days to remove the eggs from the membranes. To calculate of total fecundity, the ovaries were than processed as described by Ismen (1995a). To compare of total fecundity with results of Ismen (1995a) in the Black Sea, the fecundity-total length relationship was estimated using log transformed fecundity and length data as:

$$\text{Log (F)} = a + b \times \log(TL)$$

where F is the total fecundity, TL is the total length (cm), a is the intercept, and b is the slope of the regression line.

Size at sexual maturity was determined in females and males by calculating the proportion of mature females and males in 0.5 cm size classes. Individuals with stages 3, 4 and 5 in the gonad development stages were considered as mature. The proportion of mature females and males by size were fitted to the logistic equation:

$$P = \frac{1}{1 + e^{a+bTL}},$$

where P is the proportion of mature females or females, a and b are the coefficients of the equation, and TL is the total length. Size at sexual maturity (TL_{50}), corresponding to 50% sexually mature for females and males, was calculated from -(a/b).

Results

A total of 1952 whiting (830 females and 1122 males) were sampled between April 2011 and March 2012. Total length of females ranged between 11.6 and 30.7 cm (mean 15.72±0.06 cm) and the total length of males ranged between 10.8 and 20.4 cm (mean 15.15±0.04 cm). The mean total length of females was significantly (U-test: 3.707E05, P<0.001) greater then the mean total length of males. Looking at the overall size frequency distribution (Figure 1), dominant length interval was found between 14.5-17.0 cm for females (31.4%) and for males (42.1%).

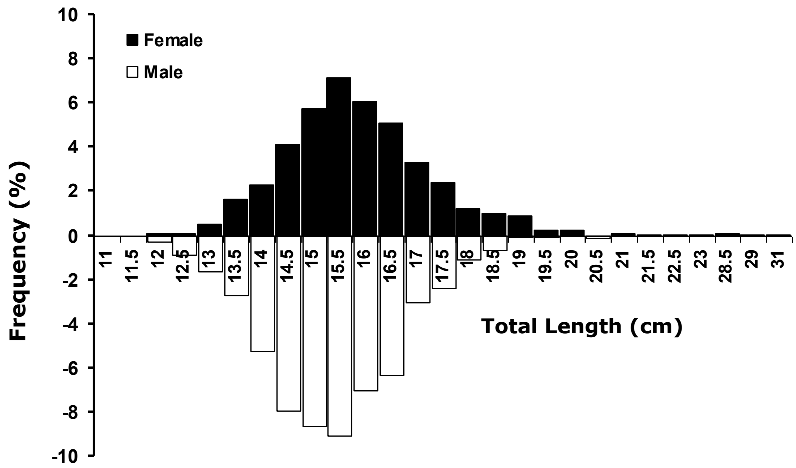

Figure 1. Length composition of females and males of whiting, *Merlangius merlangus euxinus* between April 2011 and March 2012 in the southern Black Sea.

Size frequency distribution were significantly different (Kolmogorov-Smirnov two-sample test; d = 0.15455, *P* = 1.95E-10) between females and males. Monthly length frequency distribution showed that the amount of the whiting under the legal size (13 cm total length) was found negligible level (3.6%) especially captured in April and July indicating groups of small individuals were not obtained whiting gill net fisheries in the study areas (Figure 2). On the other hand, amount of the captured whiting under the size at sexual maturity length (15 cm TL) which is calculated in this study was found important level (27.6%).

The slope of the weight-length relationship was significantly (ANCOVA; P<0.0001) different between sexes. Therefore, this relationship was separately for each sex. The relationship for females was: Log (W) = -0.0022+1.2199 Log (TL) (R^2 = 0.8789, N = 830) and for males it was: Log (W) = -1.9214+2.8135 Log (TL) (R^2 = 0.8438, N = 1122).

The slope of the regression lines for females and males were significantly different from the isometric growth curve slope (ANCOVA, P<0.0001).

The seasonal and non-seasonal von Bertalanffy growth parameters estimated from length-frequency distribution analysis (LFDA) for females and males are shown in Table1. Asymptotic total length and growth coefficient parameters were similar value for

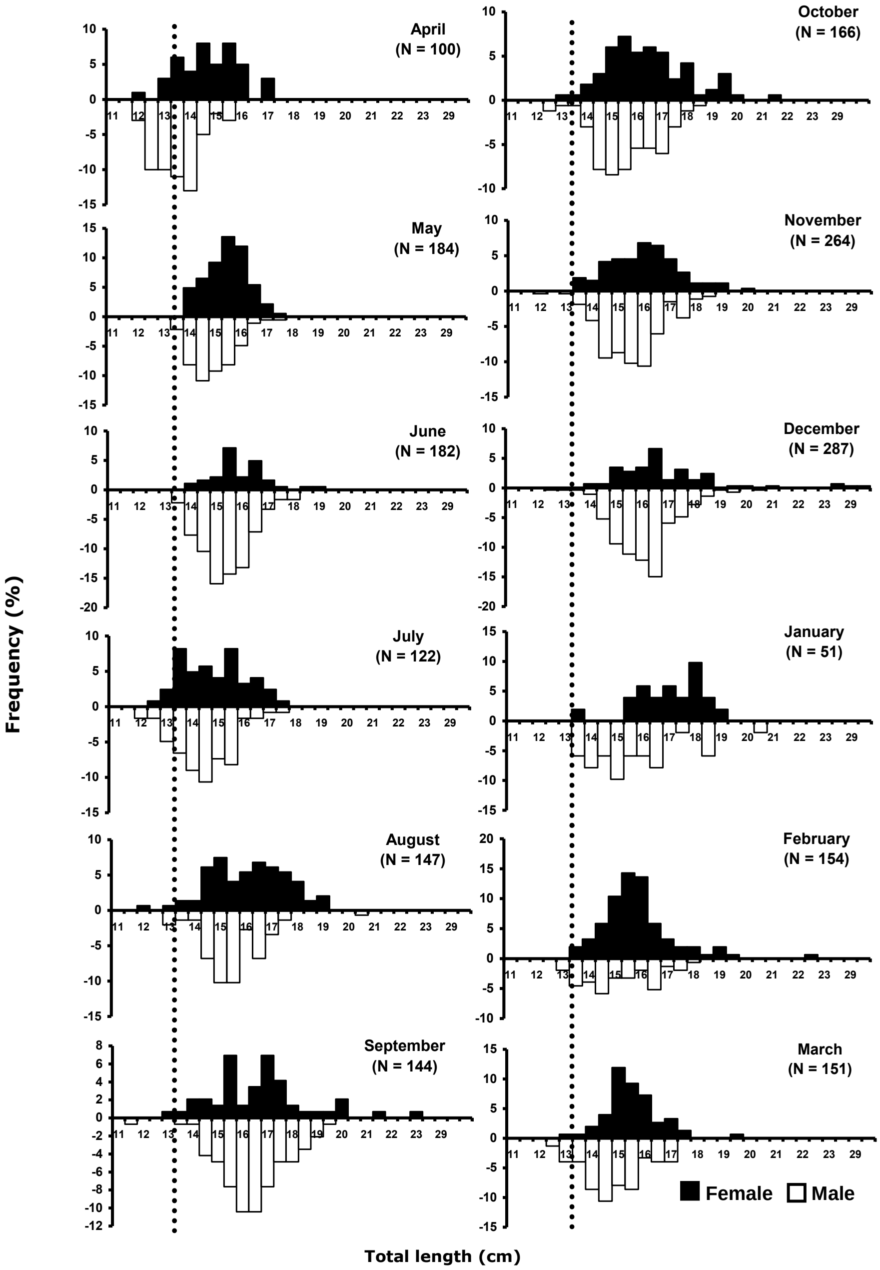

Figure 2. Montly length-frequency distribution (in percentages) of females and males of whiting, *Merlangius merlangus euxinus* between April 2011 and March 2012. Dotted line at 13 cm was drawn for illustration purposes of legal fishing length.

Table 1. Seasonal and non-seasonal von Bertalanffy growth parameters estimated from length–frequency distribution analysis for males and females

Parameters	Seasonal		Non-seasonal	
	Male	Female	Male	Female
L_∞ (cm)	18.95	20.29	18.95	20.28
K ($year^{-1}$)	0.90	0.805	0.93	0.801
t_0 (year)	-0.24	-0.76	-0.26	-0.82
WP	0.358	0.040		
ts	-0.142	-0.460		
C	0.510	0.197		
Φ′	2.509	2.520	2.524	2.518
Rn	0.464	0.283	0.430	0.274

L_∞, asymptotic total length (cm); *K*, growth coefficient ($year^{-1}$); *t_0*, age at zero length; *WP*, winter point; *ts*, the phase of the seasonal oscillations; *C*, amplitude of growth oscillation; *Rn*, goodness of fit index; *Φ′*, growth performance index.

females and males both seasonal and non-seasonal version of growth curve. On the other hand, the seasonal LFDA analyses showed that females have higher L_∞ (20.29 cm TL) than males (18.95 cm TL), whereas the growth coefficient value, *K* was higher in males (0.900) than females (0.805). Seasonal growth oscillation for males (C = 0.510) were stronger then females (C = 0.197). The start of the slowest growth period was estimated in January for females (WP = 0.040) and at the start of May for males (WP = 0.358). The Rn value of the non-seasonal growth curve improved 3.3% for males (Figure 3a, 3b) and 7.9% for females (Figure 4a, 4b) when the seasonal growth curve was fitted, indicating that, at last for our data, females exhibit a bit more seasonal growth pattern than males. Growth performance indices (Φ′) for females derived from seasonal (2.520) and non-seasonal (2.518) VBG parameters were fairly similar for males derived form seasonal (2.509) and non-seasonal (2.524) VBG parameters (Table 1).

Monthly proportion of ovaries and testes all maturity stages are exhibited in Figure 5. The stages from 1 to 4 appeared throughout the year both sexes with the exception of the stage 1 in September and March for females and stage 4 in April for males. Stage 5 was observed only in August, December and January both females and males. Individuals with stage 4 occurred in comparatively higher percentages in June, September and between December and January for females and June, September, October, December and February for males.

Looking at the monthly changes in GSI values variation (Figure 6), three peaks of GSI values were clearly exhibited in June, September, and December for females and June, October and February for males. The small individuals were also sampled middle of spring, summer and autumn (Figure 2). Despite very mixed spawning behavior of whiting, both gonad maturity stages and GSI values indicating that, at least for our data, intensive spawning probably occurred at last three times in a year; at the end of the summer, in mid-autumn and in early winter.

Size at sexual maturity was estimated from 830 females of which 528 were mature and from 1,122 males of which 752 were mature. Total length of mature females ranged between 13.5-30.7 cm and between 12.5-20.4 cm for males. The minimum length of mature fish was 13.5 cm TL for females and 12.5 cm TL for males. The relationship between total length and proportion of mature females was:

$$P = \frac{1}{1+e^{19.0-1.3*TL}}$$ and for males it was:

$$P = \frac{1}{1+e^{13.49-0.97*TL}},$$

From this, the estimated size for 50% sexual maturity (TL_{50}) was 14.6 cm TL for females and 13.9 cm TL for males (Figure 7). Total length of 34 mature female with stage 3 and 4 ranged between 13.9-28.6 cm (mean 18.3±0.6 cm) were used for fecundity estimation. Fecundity ranged between 11659 and 354204 eggs (mean 70919±11659 eggs) (Figure 8). Fecundity and total length relationship was significantly different from zero (P< 0.0001). The relationship of fecundity-total length was as:
Log F = 2.7185 *Log TL* + 1.3491 (R^2=0.7481, N=34).

Discussion

Non-seasonal growth estimates for whiting, *Merlangius merlangus euxinus*, were estimated for Black Sea stocks (Prodanov, 1980; Uysal, 1994; Samsun and Erkoyuncu, 1998; Çiloğlu et al., 2001; Ismen, 2002; Bradova and Prodano, 2003; Samsun, 2010) (Table 2). Length based growth estimates for whiting obtained with ELEFAN showed a lower L_∞ and a higher *K* for both sexes when compared to other estimates derived from otoliths. On the other hand, an attempt was made to estimate seasonal growth of the whiting by Ismen (2002) for a population in the Black Sea. However, he also estimated higher L_∞ (33.5 cm for males and 40.4 for females) and lower K (0.17 for males and 0.15 for females) than this study. Besides exploitation pressure for whiting stocks in the Black Sea, variations in the growth rates may be the result of biotic and abiotic factors such as temperature, food availability, competition, (Gerritsen *et al*., 2003; Shiganova *et al*., 2003). Different estimation of

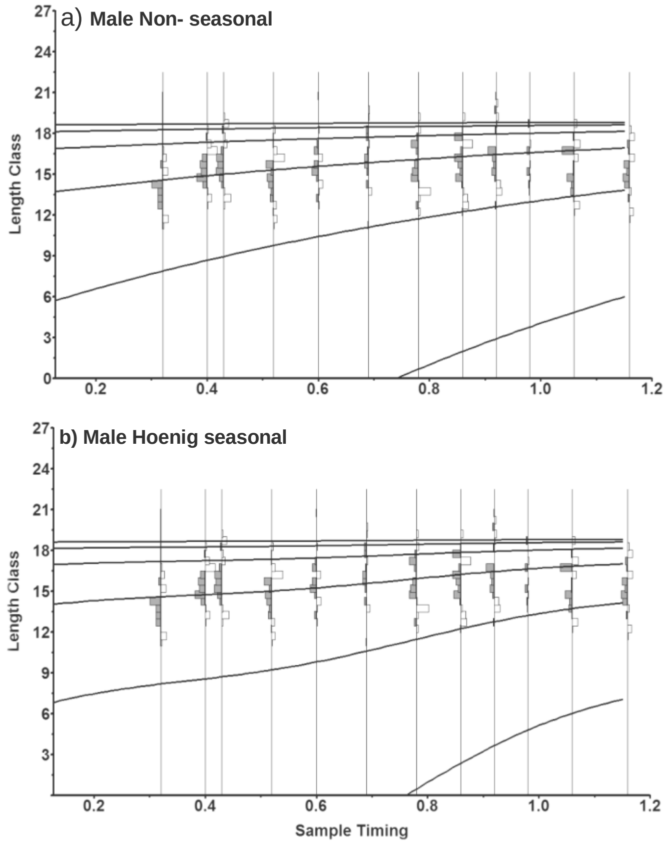

Figure 3. Length–frequency distribution of males whiting, *Merlangius merlangus euxinus* with non-seasonal (a) and seasonal (b) von Bertalanffy growth curves.

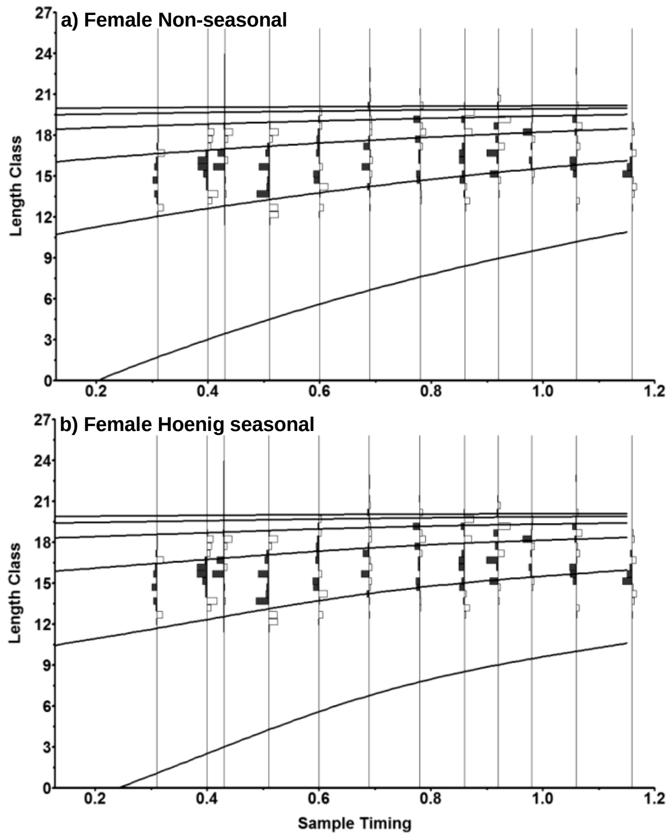

Figure 4. Length–frequency distribution of females whiting, *Merlangius merlangus euxinus* with non-seasonal (a) and seasonal (b) von Bertalanffy growth curves.

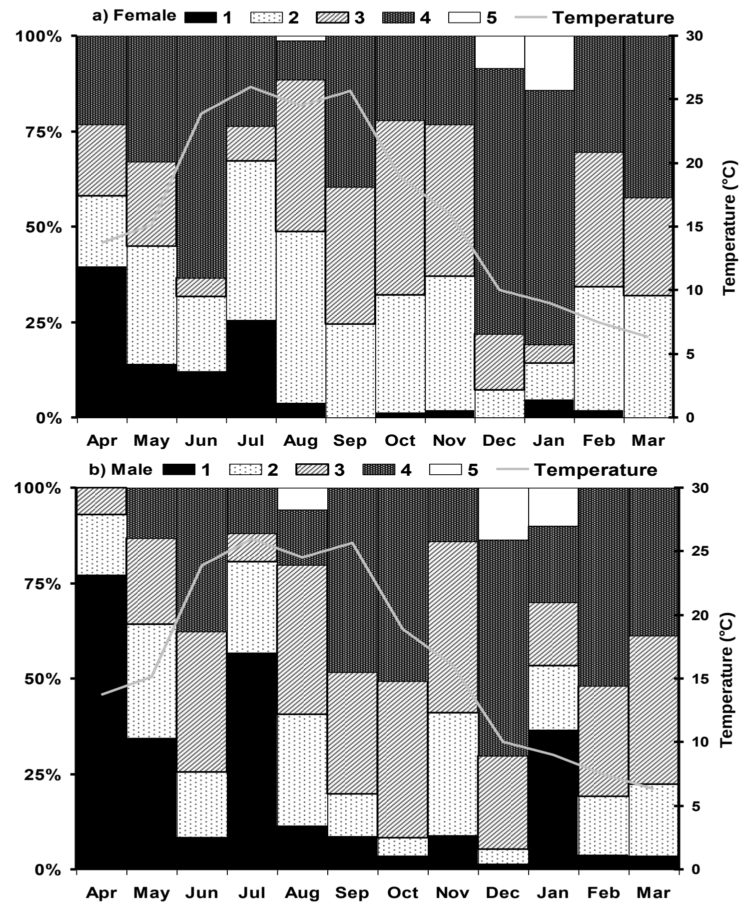

Figure 5. Monthly proportion of ovarian maturity stages (a) and testis maturity stages (b) in whiting, *Merlangius merlangus euxinus* and water temperature (^{o}C).

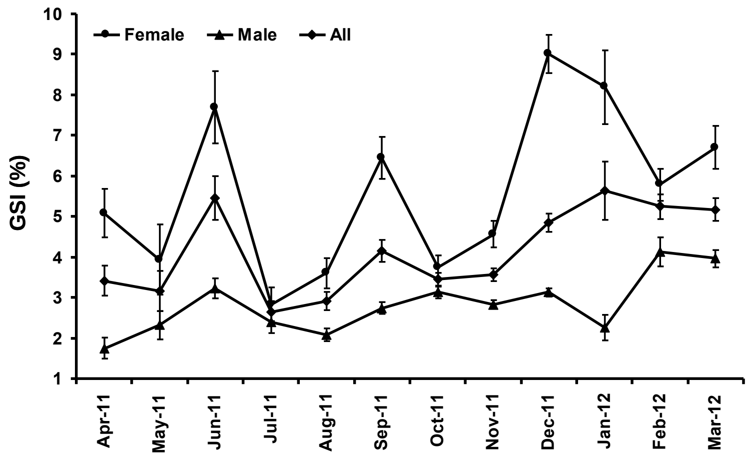

Figure 6. Monthly gonadosomatic index (GSI) with standard error (SE) of female, male and all whiting, *Merlangius merlangus euxinus* between April 2011 and March 2012.

growth rates may be the results of length composition differences between years within a stock due to different fishing pressure or/and probably due to errors associated with estimates of mean length at age. Moreover, different estimations of von Bertalanffy growth parameters can be obtained from the different methods used for calculations. Growth estimate of fish based on otoliths is more reliable than ELEFAN. According to Issac (1990), ELEFAN is more appropriate for faster growth and short lived species in contrast to long lived species because tends to overestimate K and underestimated L_{∞}. For that reason, the parameters estimated in this study should be considered as preliminary.

Seasonal growth pattern does not only differ between species but also between sexes within a

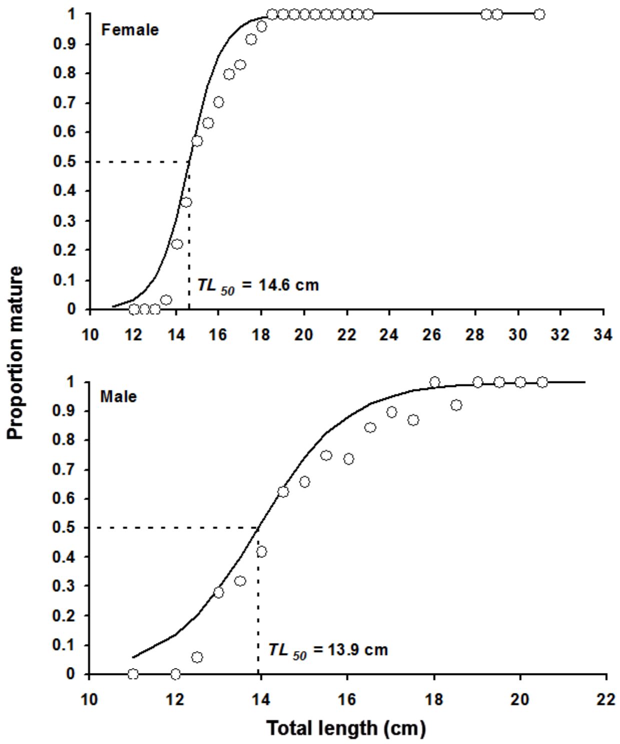

Figure 7. Logistic function fitting the proportion of whiting, *Merlangius merlangus euxinus* female and male to total length (cm). TL_{50} corresponding to proportion of 50% of female and male that are mature.

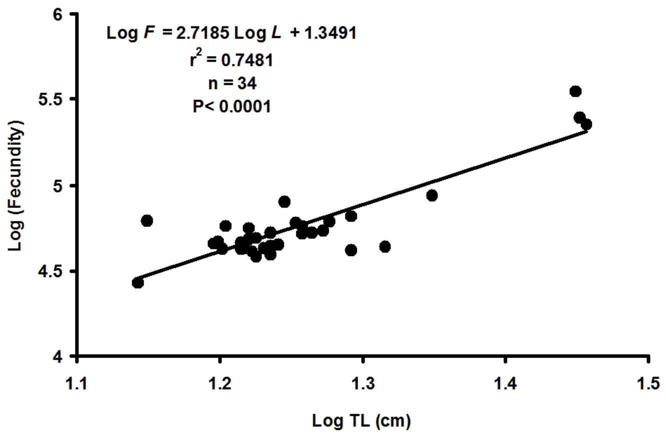

Figure 8. Logistic function fitting the logarithmic fecundity of whiting, *Merlangius merlangus euxinus* to logarithmic total length (cm).

species. Our results showed that seasonal growth oscillation of whiting was more pronounced in males (C = 0.510) than females (C = 0.197). Similarly, Ismen (2002) found that males (C = 0.560) of whiting exhibited a more pronounced seasonal oscillation than females (C = 0.240). According to Pauly, (1981) polar and temperate fish and subtropical and tropical fish generally show seasonal growth pattern. Furthermore, the growth of fish and aquatic invertebrates such as shrimp shows seasonality due to water temperature fluctuations, light cycle and food supply and energy input into reproduction during the breeding season (Hartnoll, 1985; Pauly, 1990, 1992; Mello and Rose, 2005; Bilgin *et al*., 2009).

It have been reported that food consumption of whiting is affected by water temperature and seasons. Namely, in summer when temperature raised to 18°C the food consumption was about 60-80% higher than winter when decrease in water temperature to 7-8°C (Seyhan and Grove, 1998). In the Black Sea, food consumption of whiting was intensively during spring and summer seasons (Samsun *et al*., 2011). Therefore, in the Black Sea, water temperatures fluctuate about 15°C annually, consequently resulting

Table 2. Comparison of growth and size of whiting, *Merlangius merlangus euxinus*, in the Black Sea.

References	L_∞ (cm)	K (year^{-1})	$L_{min\text{-}max}$ (L_{mean})	Φ'
Males				
Ismen, 2002	29.10	0.220	5.0-20	2.270
Çiloğlu *et al*., 2001	37.20	0.114	11-25.3	2.197
Samsun and Erkoyuncu, 1998			9.0-23	
Samsun, 2010	32.29	0.143	8.7-22.9 (14.79±0.07)	2.173
Şahin and Akbulut, 1997	35.93	0.124	8.8-21.7	2.205
Females				
Ismen, 2002	37.30	0.170	5.0-28	2.373
Çiloğlu *et al*., 2001	52.50	0.092	11-30.40	2.404
Samsun and Erkoyuncu, 1998			8.1-24	
Samsun, 2010	39.00	0.114	8.4-31.5 (15.35±0.07)	2.239
Şahin and Akbulut, 1997	45.36	0.101	9-27.7	2.316
Combined				
Ismen, 2002	37.9	0.16		2.361
Çiloğlu *et al*., 2001				
Samsun and Erkoyuncu, 1998	35.45	0.138	14.53±0.07	2.239
Samsun, 2010	39	0.115	15.06±0.05	2.242
Bradova and Prodano, 2003	26.63	0.223		2.199
Prodanov, 1980	31.42	0.145		2.155
Uysal, 1994	41.8	0.14		2.388
Maximov *et al.*, 2007	26.30	0.160		2.044

L_∞, asymptotic total length (cm); K, growth rate (year^{-1}); Φ', growth performance index; L_{min}, minimum total length (cm); L_{max}, maximum total length (cm); L_{mean}, mean total length (cm).

in a seasonal growth pattern of whiting in this population.

The time of the slowest growth for females corresponded to January (*WP* = 0.040), the period with relatively low water temperature (8°C). The time of the slowest growth period for males, however, was estimated as May (*WP* = 0.358) the period with start of activity of testis (Fig. 5b). In the early study the slowest growth period of whiting in the Black Sea was estimated as September (*WP* = 0.75) for males and November (*WP* = 0.85) for females corresponded to spawning period (Ismen, 2002).

Growth performance index (Φ') is useful for evaluation of growth under a variety of environmental stresses (Pauly, 1991). The growth performance indices, calculated from different studies (Table 2), for females were always greater than it was for males for the whiting stocks, displaying that female whiting grew relatively faster and reached a larger asymptotic length at age compared to males in the Black Sea. Our results of Φ' were relatively similar from different studies.

According to gonad maturity stages and GSI variations, reproduction activity of whiting continued during the year and intensively spawning occurred at last three times in a year; at the end of the summer, in mid-autumn and in early winter. In the early literature, the spawning time of whiting was declared almost throughout the whole year (Ismen, 1995b; Çiloğlu *et al*., 2001; Samsun, 2005). However, maximum spawning of whiting were reported between December and May (Samsun, 2005; Şahin and Akbulut, 1997), between October and July (Ismen, 1995b) and between January and August (Çiloğlu *et al*., 2001) in the Black Sea coast of Turkey.

Ismen (1995a) reported that the fecundity of whiting for the eastern Turkish Black Sea coast is highly correlated with total length by the relationship Log F = 2.744 Log TL + 1.585. These results are consistent with the relationship found in our study.

Size at sexual maturity (TL_{50}) was estimated as 14.6 cm for females and 13.9 cm for males. Size at sexual maturity of the whiting was estimated as 14.7 cm for females and 12.5 cm for males (Ismen, 1995b) and 13.8 cm for females and 12.9 cm for males Samsun, 2005) in the Black Sea coast of Turkey. The variation of sexual maturity length may be the result of differences in sampling procedure such as sampling gear and location. Furthermore, 50% selection size (L_c) was estimated as 15.7 cm for whiting caught by bottom trawl with 20 mm cod-end mesh size in the Black Sea (Erkoyuncu and Samsun, 1989). Our study showed that protection of whiting breeding and for a sustainable whiting fishery with bottom gill nets, the smallest capture size should be applied as 15 cm TL. Note that, whiting fishing with bottom gill nets in Turkey is conducted with 13 cm TL limitation (Anonymous, 2008). Finally, this study should be helpful results for Turkish fisheries managers (e.g. The General Directorate for Fisheries and Aquaculture) to organized sustainable fishery management in the Black Sea whiting populations.

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