Research Article

Biological characteristics of the common pandora, *Pagellus erythrinus* (Linnaeus, 1758), in the central Aegean Sea

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Abstract: We investigated the length distribution, sex ratio, sex inversion length, length-weight relationship, age, growth, spawning period, age and length at first maturity of the common pandora inhabiting İzmir Bay. A total of 2654 common pandora were collected by trawl hauls of İzmir Bay (Turkey) between January 2002 and June 2007. The size of the samples ranged from 4.1 cm (0.95 g, February) to 27.8 cm (207.30 g, April) in total length. The samples were composed of 64.7% females, 5.1% males, 0.3% hermaphrodites, and 29.9% immature individuals, with a female to male ratio of 1:0.08. The age composition of the samples ranged between 1 and 10 years. The length-weight relationship and the von Bertalanffy growth function were estimated for all individuals as: $W = 0.0143L^{2.95}$ and $L_t = 30.673[1 - e^{-0.165(t - (-0.857))}]$. The spawning period started in June and continued until October. The total lengths at first maturity of females and males were 11.30 and 15.08 cm, respectively.

Key words: Common pandora, *Pagellus erythrinus*, Aegean Sea, length-weight relationship, age, growth, spawning period, first maturity length

Orta Ege Denizi kırma mercan balığı'nın (*Pagellus erythrinus* (Linnaeus, 1758)) biyolojik özellikleri

Özet: Bu çalışmada İzmir Körfezi kırma mercan stoğuna ait; boy dağılımı, cinsiyet oranı, cinsiyet dönüşüm boyu, boy-ağırlık ilişkisi, yaş, büyüme, yumurtlama zamanı, ilk üreme yaşı ve boyu incelenmiştir. Toplamda 2654 adet kırma mercan bireyi Ocak 2002 - Haziran 2007 tarihleri arasında İzmir Körfezi'nden dip trol ile örneklenmiştir. Örneklerin, 4,1 (0,95 gr, Şubat) ile 27,8 cm (207,30 gr, Nisan) total boyları arasında dağılım gösterdikleri tespit edilmiştir. Bireylerin; %64,7'sinin dişi, %5,1'inin erkek, %0,3'ünün hermafrodit, %29,9'unun ise cinsi olgunluğa ulaşmamış bireylerden oluştuğu tespit edilmiş olup, stoğa ait cinsiyet oranı 1:0,08 olarak hesaplanmıştır. Örneklerin, 1 ile 10 yaşları arasında dağılım gösterdiği tespit edilmiştir. Tüm bireylere ait boy-ağırlık ilişkisi ve von Bertalanffy büyüme eşitliği $W = 0,0143L^{2.95}$ ve $L_t = 30,673[1 - e^{-0.165(t - (-0.857))}]$ olarak hesaplanmıştır. Yumurtlamanın Haziran ayında başladığı ve Ekim'e kadar sürdüğü gözlenmiştir. Dişi ve erkek bireyler için ilk üreme boyunun sırasıyla 11,30 ve 15,08 cm total boy olduğu hesaplanmıştır.

Anahtar sözcükler: Kırma mercan, *Pagellus erythrinus*, Ege Denizi, boy-ağırlık ilişkisi, yaş, büyüme, üreme zamanı, ilk üreme boyu

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Introduction

The common pandora, *Pagellus erythrinus* (Linnaeus, 1758), which belongs to the family Sparidae, is a valuable species for aquaculture and fisheries. The species has a relatively wide distribution, inhabiting the Black and Mediterranean seas and from Norway to Angola (Bauchot and Hureau, 1986). The depth range of the common pandora varies generally between 20-100 m and 320 m down in various habitats (Bouchot, 1987). Özaydın (1997), Tosunoğlu et al. (1997), Stergiou and Moutopoulos (2001), and Hoşsucu and Çakır (2003) have all conducted studies on population characteristics of the species inhabiting the Aegean Sea. Furthermore, Relini and Romeo (1985), Vasilipoulou et al. (1986), Papaconstantinou et al. (1988), Mytilinénou (1989), Livadas (1989), and Pajuelo and Lorenzo (1998) have researched biological characteristics of the species from different seas. Valdés et al. (2004), reported that the common pandora is a suitable species for aquaculture in the Mediterranean and that the correct determination of the species' spawning period is also very important. The common pandora is of commercial importance and has been captured by gill or trammel nets, longline, and trawl in İzmir Bay. The production amount of all pandora species including the common pandora is 689 t, which corresponds to 0.13% of total production according to the Turkish Statistical Institute (Turkstat, 2007).

The main objective of this study was to investigate length distribution, sex ratio, sex inversion length, length-weight relationship, age, growth, spawning period, first maturity age and length of the common pandora for the central Aegean Sea. The findings were compared with previous studies and discussed from the perspective of a sustainable fisheries policy.

Materials and methods

A total of 2654 common pandora samples were collected with trawl hauls from İzmir Bay (38°40′N; 26°31′E and 38°2′N; 26°8′E), between depths of 30 and 70 m by R/V Egesüf (26.8 m length, 463 HP engine and 110 gross weight) from January 2002 to June 2007. A commercial bottom trawl was used for sampling. The cod-end used featured a knotless diamond shape and was made of polyamide (PA) material with 22 mm stretched mesh size netting.

Fish samples were brought to the laboratory and total length (L) was measured to the nearest millimeter in the natural body position. Total weight (W) and gonad weight (W_g) was measured to the nearest 0.01 g, and sex was recorded. Fish lengths were classified in 0.5 cm group intervals and length-frequency diagrams were drawn yearly. Sagittal otolith pairs were removed for each length group, cleaned and stored in dry conditions inside the microplate.

Sex and maturity were determined by macroscopic analysis of the gonads. The maturity stages were assessed according to Gunderson's (1993) scale: stage I, immature; stage II, resting; stage III, developing; stage IV, ripe; and stage V, spent. The sex ratio (female:male) was calculated for the stock using the mature individuals after the elimination of immature ones. A chi-square test was used to determine the significance of the male to female ratio.

The relationship between length and weight was established as $W = aL^b$, where W is total body weight (g), L is total length (cm), and a and b are coefficients (Ricker, 1973). The parameters a and b of length-weight relationships were estimated by linear regression analysis on log-transformed data. The association degree between variables was calculated by the determination coefficient (R^2). The growth type was identified by use of Student's t-test.

The otoliths of 670 individuals (representing all size classes sampled) were used to identify the age. Considering their physical and chemical characteristics, some otoliths were prepared for age readings by profiling, rubbing, and polishing. They were imbedded in polyester molds, cut by an IsoMet Low Speed Saw, polished with sandpaper (types 400, 800, and 1200), and finally polished with 3, 1, and ¼ μ particulate alumina (Metin and Kınacıgil, 2001). Age determination was performed using a stereoscopic microscope under reflected light against a black background. Opaque and transparent rings were counted: 1 opaque zone, together with 1 transparent zone, was considered the annual growth indicator. Age estimations were made by 2 independent readers (Figure 1).
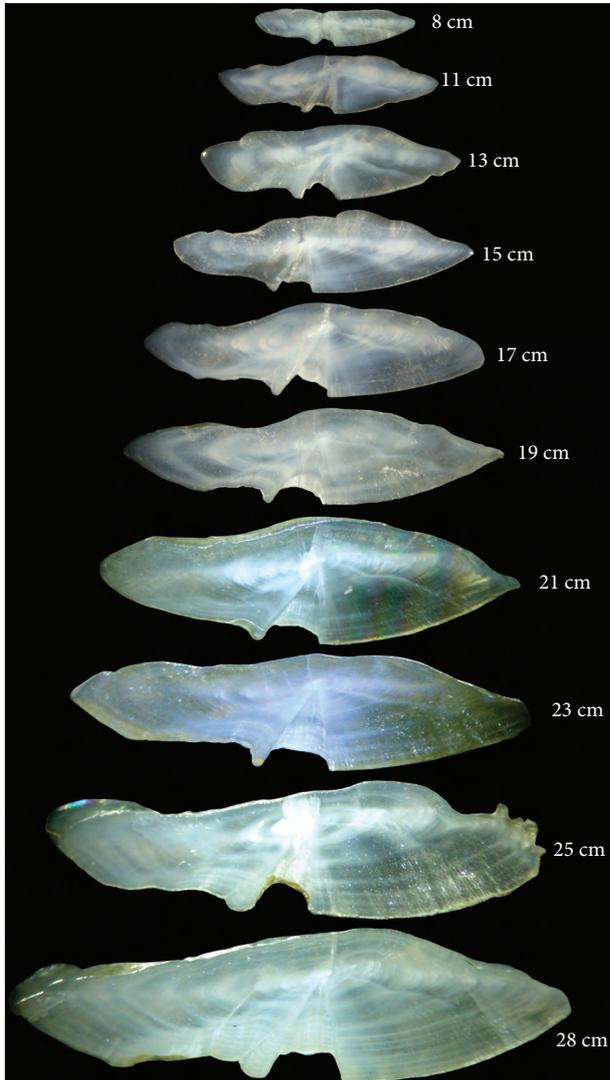
Figure 1. Samples of otolith sections belonging to different length individuals of the common pandora.

Growth was analyzed by fitting the von Bertalanffy growth function to size-at-age data using standard nonlinear optimization methods (Sparre and Venema, 1998). The function $L_t = L_\infty[1 - e^{-k(t - t_o)}]$ was applied to the data where L_t is the fish length (cm) at the time t (year), L_∞ is the asymptotic length (cm), k is the growth coefficient (year^{-1}), and t_o (year) is the hypothetical time at which the length is equal to zero. The accuracy of the growth parameters was tested using Munro's growth performance index ($\varphi' = \log(k) + 2\log(L_\infty)$) and t-test (Pauly and Munro, 1984). The asymptotic weight was calculated by W_∞

$= aL_\infty{}^b$, where L_∞ is the asymptotic length (cm), a is the intercept and b is the slope of length-weight relationships.

The spawning period was established with monthly variations of the gonadosomatic index (GSI) from the equation $GSI = [W_g / (W - W_g)] \times 100$, where W_g is the gonad weight (g), and W is the total weight (g) of fish (Ricker, 1975).

Length at first maturity (L_m) was defined as the length at which 50% of the population investigated was near to spawning (King, 1996). The LogLog function was used to assess the proportion of mature individuals by size class using a nonlinear regression with the L50 computer program (İlkyaz et al., 1998). The equations $r(l) = \exp(-\exp(-(a + bl)))$ and $L_m = (-\ln(-\ln(0.5)) - a) / b$ were applied, where $r(l)$ is the proportion of mature specimens in each length class (%), l is the fish length (cm), L_m is the mean length at sexual maturity (50%, cm), a is the intercept and b is the slope. The sex inversion length (FM_{50}) was estimated as the length at which the sex ratio is equal for female and male. For the estimation, the Logit function was used with the same computer program. The equations $r(l) = (\exp(a + bl)) / (1 + \exp(a + bl))$ and $FM_{50} = -a / b$ were applied. Before the determination, the female and male length distribution data was transformed using the normal distribution function. For the normalization, the standard deviation of the pooled female and male data was used.

Results

In this study, a total of 2654 individuals were sampled during the study period. It was determined that 64.7% of the samples were females ($n = 1717$), 5.1% males ($n = 136$), 0.3% hermaphrodite ($n = 8$) and 29.9% immature ($n = 793$). The sex ratio was calculated as 1:0.08 and chi-square analysis showed that it is statistically significant (x^2, P < 0.05).

The total length-frequency distribution of the common pandora is shown in Figure 2. The minimum size observed in February was 4.1 cm (0.95 g) while the maximum size found in April had a total length of 27.8 cm (207.30 g). The average total length and total weight of the individuals was calculated as 13.0 ± 0.1 cm and 33.24 ± 0.66 g ($\bar{x} \pm se$), respectively. It was determined that females ranged in length
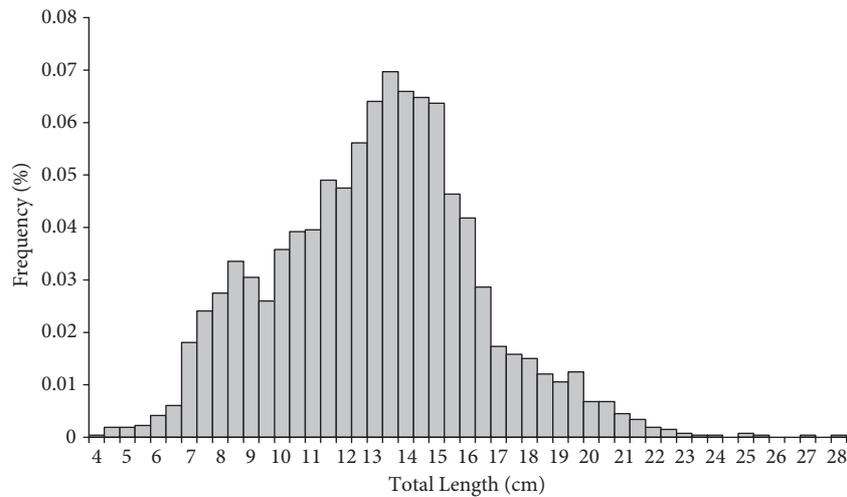
Figure 2. Total length-frequency distribution of the common pandora.

between 6.2 and 24.9 cm, males ranged between 7.8 and 27.8 cm, and that the range was 11.3 and 20.8 cm for hermaphrodites.

Because there was significant statistical difference between the values of male and female individuals, the length-weight regression was calculated separately for females, males, and all samples (Table 1). The length-weight relationship for hermaphrodites couldn't be calculated because of insufficient sample size. The calculated length-weight equation was $W = 0.0143L^{2.95}$ ($R^2 = 0.99$) for all samples (Figure 3). The *b*-values showed significant difference in isometric growth for females and all samples (P < 0.05), but no significant difference for males (*t*-test, P > 0.05)

It was determined that the age distribution of individuals varied between 1 and 10 years. The asymptotic length (L_∞) was 30.67 cm; the asymptotic weight (W_∞) was 345.41 g; the theoretical age of the fish prior to hatching from the egg was (t_o) −0.857 year; and the growth coefficient (*k*) was 0.165 year^{-1} ($R^2 = 0.998$). For all fish, the growth model was $L_t = 30.673[1 - e^{-0.165(t - (-0.857))}]$ (Figure 4) and the growth performance index (φ') was calculated as 2.19.

Monthly average gonadosomatic index (*GSI*) values of females and males are given in Figure 5. Based on the gonadosomatic index values, it can be said that the species has a relatively long spawning period. In both sexes, gonads start to mature in April. Maximum gonadosomatic index value was recorded in June for females (2.24) and May for males (2.70). It was determined that the spawning period of the common pandora occurs in June and October.

Table 1. The length-weight relationships of the common pandora.

	n	*a*	*b*	R^2	SE_b	*95% CL of b*	*GT*
All samples	2654	0.0143	2.95	0.99	0.006	2.94 - 2.96	−A
Female	1717	0.0107	3.06	0.98	0.010	3.04 - 3.08	+A
Male	136	0.0125	2.99	0.99	0.023	2.95 - 3.04	I

n: number of specimens; *a* and *b*: intercept and slope of the relationship; R^2: coefficient of determination; SE_b: standard error of slope; *CL*: confidence limits; *GT*: growth type (I: isometric; A: allometric)
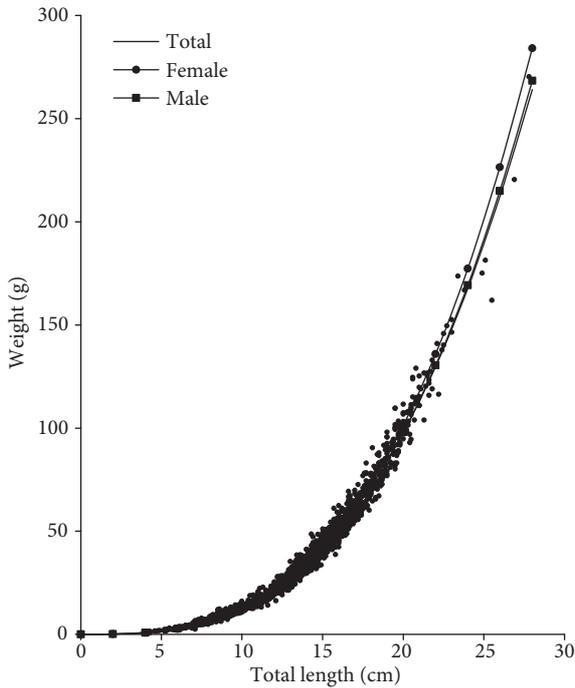
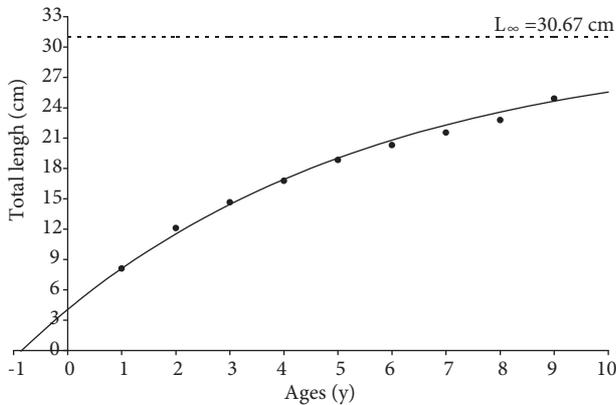Figure 3. The length-weight relationships of the common pandora.

Figure 4. The von Bertalanffy growth curve for the common pandora.

It was observed that the smallest female was 6.2 and the male was 7.8 cm total length. Gonad maturity in 50% of the individuals was found at 11.30 for females ($a = -8.221$, $b = 0.728$, $R^2 = 0.971$) and 15.08 cm total length for males ($a = -12.662$, $b = 0.840$, $R^2 = 0.913$) (Figure 6). The sexual maturity age was found to be 2 for female, 3 for male. The sex inversion length (FM_{50}) was estimated at 15.26 cm total length ($\bar{x}_f = 14.20$, $\bar{x}_m = 16.37$, $sd_{f+m} = 2.71$, $a = 4.473$, $b = -0.293$) (Figure 7).

Discussion

The sex ratio is an important parameter for fish stocks and this ratio is generally close to 1:1 for the majority of species (Nikolsky, 1963). However, our findings showed a statistically significant difference from this equality. The predominance of females can be explained by protogenus hermaphroditism and an abundance of young individuals among the stock. Pajuelo and Lorenzo (1998) reported that the sex ratio of the species was skewed in favor of females inhabiting the Canary Islands. Vassilopoulo et al. (1986) reported the predominance of females has also been observed in the Mediterranean. Studies carried out in the Aegean and Mediterranean seas also confirmed the predominance of females (Hashem and Gassim, 1981; Ünsal, 1984; Mytilineou, 1989; Özaydın, 1997; Hoşsucu and Çakır, 2003).

The b-value in the length-weight relationship showed that although growth was isometric for males, positive allometric growth was determined for females. For the overall population sampled, negative allometric growth type was observed. Studies conducted in both the Aegean Sea and the Mediterranean Sea generally found results with negative allometric growth (Rijavec and Lupanovic, 1965; Andaloro and Giarritta, 1985; Vassilipoulo et al., 1986; Livadas, 1989; Özaydın, 1997; Hoşsucu and Çakır, 2003). On the other hand Ghorbel (1981), Mytilineou (1989), and Pajuelo and Lorenzo (1998) reported isometric growth for the common pandora. The b-values are often 3.0 but can range between 2.5 and 3.5 and in each fish population may differ according to the species, sex, age, sexual maturity of the fish as well as the season and fish feeding (Ricker, 1975).

The sagittal otoliths were used to identify age. For age determination based on scale, Somarakis and Machias (2002) reported that the seasonal pattern in mean marginal increment was less clear for ages greater than 4 because the sample size was small. Similarly, age determination becomes difficult as the age increases because the age rings come closer in the sagittal otoliths. For this reason, age determination was carried out with otolith sections, which was found to be a convenient method for age determination of the species.
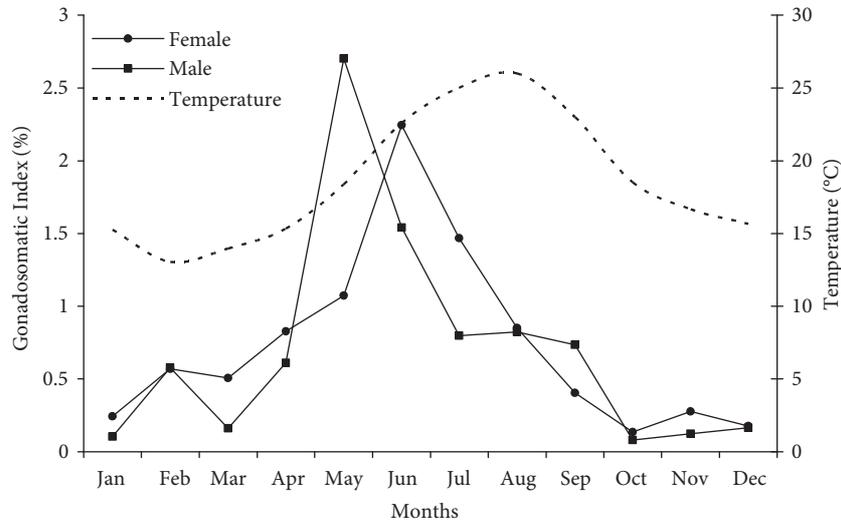
Figure 5. A comparison between gonadosomatic index (GSI) values (%) of males and females by month for the common pandora and monthly surface temperatures in the sampling area.
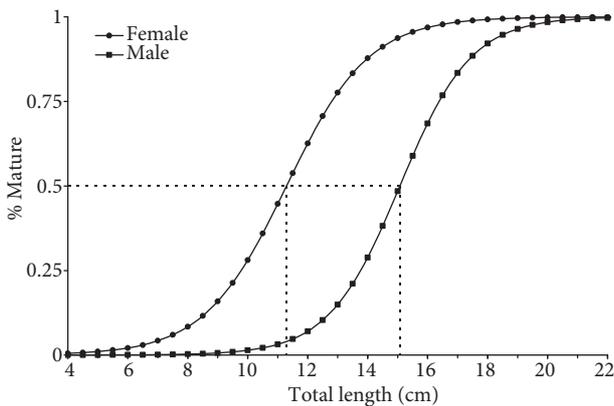

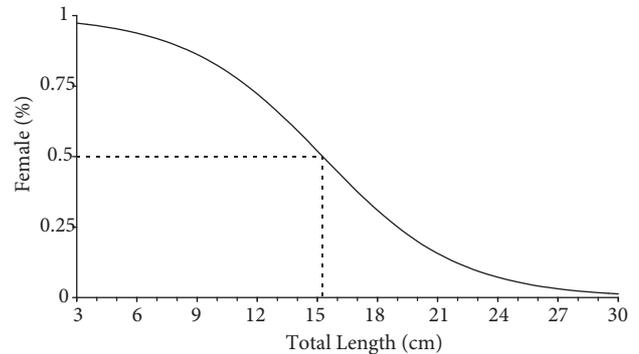Figure 6. Estimation of the length at first maturity of the common pandora.

Figure 7. Percentage of sex inversion for the common pandora.

It was observed that the stock was composed of 1 to 10 year old individuals. Female individuals ranged between 1 year (6.2 cm) to 8 years (24.9 cm) and male individuals from 1 to 10 years (7.8-27.8 cm) while hermaphrodite samples were between 2 and 6 years (11.3-20.8 cm). Hoşsucu and Çakır (2003) determined the maximum age as 8 ($\overline{x}$ = 20.83 cm, fork length) in Edremit Bay; Mytilineou (1989) reported the maximum age as 11 ($\overline{x}$ = 26.5 cm) in Greece; and 10 years of age ($\overline{x}$ = 37.1 cm) was determined as the maximum according to Pajuelo and Lorenzo

(1998) for the Canary Islands. In southern Portugal, Abecasis et al. (2008) determined the maximum age as 21 (40 cm) by otolith observations and 21 (40 cm) by scale analyses. Bouchot (1987) reported that male individuals of protogenus hermaphrodite species began to appear from nearly 3 years of age (17-18 cm), but this study reported males from the beginning of 1 year (7.8 cm). Nevertheless, sex inversion length for the stock was determined as 15.26 cm and this value is slightly higher than the first reproduction length of males. According to these results it may be proposed

that the stock needs to involve smaller males to reach the required number of males for preventing the reproductive ability.

The asymptotic length (L_∞) was determined as 30.67 cm total length. In the Aegean and Mediterranean seas, this value was found to be 24 cm fork length according to Hoşsucu and Çakır (2003) in Edremit Bay; Tosunoğlu et al. (1997) reported findings of 35.7 cm for Gülbahçe Bay; in Sicily, it was 36.7 cm according to Andalaro and Giarritta (1985); Girardin and Quignard (1985) determined the value to be 34.5 cm in the Bay of Lyon; it was calculated to be 32.6 cm by Papaconstantinou et al. (1988) in Greece. Similarly, Livadas (1989) found 30 cm for Cyprus while Somarakis and Machias (2002) reported 27.8 cm on the Cretan Shelf. Calculated asymptotic length values ranged between 24 and 36.7 cm in the middle and eastern Mediterranean. Representing the western Mediterranean and eastern Atlantic, asymptotic length values were determined at 51.7 cm by Larrañeta (1967) in Castellon and 41.7 cm by Pajuelo and Lorenzo (1998) in the Canary Islands. These findings identified the difference

in the growth of the species between the eastern Atlantic, western Mediterranean, and eastern Mediterranean regions. The differences in growth probably depend on the ecological conditions in the areas of investigation (Shepherd and Grimes, 1983). Somarakis and Machias (2002) and Stergiou et al. (1997) reported that the occurrence of short length (dwarfism) in benthic invertebrates inhabiting the eastern Mediterranean may also be valid for fish species. The growth performance index (φ') was calculated as 2.19 for this study and this parameter has been calculated between 1.96 and 2.59 in previous studies (Table 2). Statistical analysis showed that there was no significant difference between the growth performance indexes of the other study areas (*t*-test, P > 0.05).

Maximum gonadosomatic index value was detected in June for females and May for males. It was observed that spawning started in June and continued until October. Hoşsucu and Çakır (2003) reported that the common pandora has a long spawning period, occurring between April and October in Edremit Bay. Spawning occurs

Table 2. A comparison between growth parameters of the common pandora for the present study and those conducted in different geographic areas.

Geographic Area		L_∞	k	t_o	φ'	Author(s)
EA	(Canary Islands)	41.8	0.21	−0.55	2.56	Pajuelo and Lorenzo (1998)
WM	(Castellon)	51.7	0.14	−1.12	2.57	Larrañeta (1967)
WM	(Lyon Bay)	34.5	0.33		2.59	Girardin and Quignard (1985)
CM	(Sicilia)	36.7	0.16		2.33	Andalaro and Giarritta (1985)
EM	(Greece)	32.6	0.18		2.28	Papaconstantinou et al. (1988)
EM	(Cyprus)	30.0	0.20		2.26	Livadas (1989)
EM	(Cretan Shelf)	27.8	0.32	−0.74	2.39	Somarakis and Machias (2002)
EM	(Gülbahçe Bay)	35.7	0.10	−2.37	2.11	Tosunoğlu et al. (1997)
EM	(Edremit Bay)	24.0	0.16	−2.60	1.96	Hoşsucu and Çakır (2003)
EM	(İzmir Bay)	30.7	0.17	−0.86	2.19	The present study

Geographic Area EA: eastern Atlantic, WM: western Mediterranean, CM: central Mediterranean, EM: eastern Mediterranean; L_∞, k and t_o: parameters of the von Bertalanffy growth equation; φ': Munro's growth performance index.

between May-September according to many studies (Larrañeta 1964; Girardin and Quignard, 1985; Papaconstantinou et al., 1988; Livadas, 1989). Pajuelo and Lorenzo (1998) determined that this species reproduces in the period of the highest water temperature in the Canary Islands. According to Valdés et al. (2004), the common pandora spawns in water temperatures between 22 and 24 °C and the eggs lose water at higher temperatures. The same research states that a rise in temperature causes abnormalities in eggs; therefore, spawning declines in periods with high water temperature. In our study, the maximum gonadosomatic index value was obtained in June and most of the spawning activity occurred by July. An analysis of the surface water temperature in the same period determined that 22.6 °C was the optimum water temperature for the spawning of the common pandora. Although spawning continued in July, it showed a significant decrease and the average temperature was 25 °C in this month. Similarly, Valdés et al. (2004) reported the first water-bulged eggs of the common pandora in June in Mazzaron Bay, with an analyzed water temperature of 23.2 °C.

In this study, first gonad formation started at 6.2 cm total length in females and 7.8 cm total length in males. The length at which 50% of the stock ovulated gonads was determined to be 11.30 cm for females and 15.08 cm for males. Hoşsucu and Çakır (2003) reported 13 cm (*FL*) as the first reproduction length of females while Somarakis and Machias (2002) found this value 13.4 cm for females and 14.2 cm fork length for males. Pajuelo and Lorenzo (1998) calculated the same value as 17.4 and 23.2 cm for females and males, respectively. This difference can be explained

by different bio-ecological conditions. Furthermore, Somarakis and Machias (2002) reported that because the eastern Mediterranean has much lower food availability and higher temperatures than the western Mediterranean and Atlantic, this combination may lead to the significantly lower figures seen for lengths-at-age, asymptotic sizes, and age/length at 50% maturity.

Ultimately, the common pandora is of commercial importance as an important species for recreational and commercial fisheries. For this reason, legal regulations are required regarding the fisheries of the species. The findings of this present study can be used to determine the appropriate fishing period and fish size for sustainable fishing of this species. Gonadosomatic index values were used to determine the prohibited fishing period. Recommendations about the minimum length and legal regulations depend on the findings of the first reproduction length and the length at which females and males have equal numbers of individuals. On the basis of these considerations, it may be suggested that fishing of the species between June and September be prohibited, and the minimum length limit should be set at 16 cm.

Acknowledgments

References

Abecasis, D., Bentes, L., Coelho, R., Correia, C., Lino, P.G., Monteiro, P., Gonçalves, J.M.S., Ribeiro, J. and Erzini, K. 2008. Ageing seabreams: A comparative study between scales and otoliths. Fish. Res. 89: 37-48.

Andaloro, F. and Giarritta, S.P. 1985. Contribution to the knowledge of the age, growth and feeding of pandora, *Pagellus erythrinus* (L. 1758) in the Sicilian channel. FAO Fish. Rep. 336: 85-87.

Bauchot, M.L. and Hureau, J.C. 1986. Sparidae. In: Fishes of the North-Eastern Atlantic and Mediterranean (ed. P.J.P. Whithead, M.-L. Bauchot, J.C. Hureau, J. Nielsen and E. Tortonese), UNESCO, Paris, pp. 883-907.

Bouchot, M.-L. 1987. Sparidae. In: Mediterranee ét mer Noire, Zone de pêche 37, Révision 1, Volume II, Vertebres (ed. W. Fischer, M. Schneider and M.-L. Bouchot), FAO, Rome, pp.1343-1376.

Ghorbel, M. 1981. Contribution à l'étude morphologique et biologique des poissons Pagellus et Lithognathus de Tunisie; étude dynamique preliminaire du pageau dans le Golf de Gabes. Rapport de Stage, DEA de biologie marine et d'Oceanographique, Faculte des Sciences de Tunis, 139pp.

Girardin, M. and Quignard, J.P. 1985. Croissance de *Pagellus erythrinus* (Pisces: Téléostéens Sparidae) dans le Golf edu Lion. Cybium 9: 359-374.

Gunderson, D.R. 1993. Surveys of fisheries resources. John Wiley & Sons, Inc. New York.

Hashem, M.T. and Gassim, A.S. 1981. Some aspects of the fishery biology of *Pagellus erythrinus* (L.) in the Libyan waters. Bull. Inst. Oceanogr. & Fish. ARE 7: 429-441.

Hoşsucu, B. and Çakır, D.T. 2003. Some Parameters about Population Biology of the Common Pandora (*Pagellus erythrinus* L., 1758) (Sparidae) in the Edremit Bay (Turkey). E.U. J. Fish. & Aquat. Sci. 20: 329-336.

İlkyaz, A.T., Metin, C. and Kınacıgil, H.T. 1998. A computer program about the calculation of the selectivity parameters in towed fishing gear illustrated with cover cod-end method (L50 Version: 1.0.0). E.U. J. Fish. & Aquat. Sci. 15: 305-314.

King, M., 1996. Fisheries Biology Assessment and Management. Fishing News Books, England.

Larrañeta, M.G. 1964. Sobre la biología de *Pagellus erythrinus* (L.) especialmente del de las Costas de Casrellón. Inv. Pesq. 27: 121-146.

Larrañeta, M.G. 1967. Crecimiento de *Pagellus erythrinus* de las costas de Castellón. Inv. Pesq. 31: 185-258.

Livadas, R.J. 1989. A study of the biology and population dynamics of pandora (*Pagellus erythrinus* L., 1758) family Sparidae in the Seas of Cyprus. FAO Fish. Rep. 412: 58-75.

Metin, G. and Kınacıgil, H.T. 2001. The sectioning technique in age determination by otolith. E.U. J. Fish. & Aquat. Sci. 18: 271-277.

Mytilineou, C. 1989. Donnees biologiques sur le pageot, *Pagellus erythrinus*, des cotes orientales de la Grece centrale. FAO Fish. Rep. 412: 77-82.

Nikolsky, G.W. 1963. The Ecology of Fishes. Academic Press, London and New York.

Özaydın, O. 1997. Biology and feeding ecology of some Sparid species living in Aegean Sea, PhD thesis, DEÜ, İzmir, 137 pp.

Pajuelo, J.G. and Lorenzo, J.M. 1998. Population biology of the common pandora *Pagellus erythrinus* (Pisces: Sparidae) of the Canary Islands. Fish. Res. 36: 75-86.

Papaconstantinou, C., Mytileneou, C. and Panos, T. 1988. Aspects of the life history and fishery of red pandora, *Pagellus erythrinus* (Sparidae), off western Greece. Cybium 132: 159-167.

Pauly, D. and Munro, J.L. 1984. Once more on growth comparison in fish and invertebrates. ICLARM, Fishbyte 2: 21.

Rellini, L.O. and Romeo, G. 1985. Vertical distribution, age, growth and mortality of *Pagellus erythrinus* on trawled coastal areas of the Ligurian Sea. Rapp. Comm. Int. Mer Médit. 29: 103-106.

Ricker, W.E. 1973. Linear regressions in fishery research. Fish. Res. Board Can. 30: 409-434.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191: 1-382.

Rijavec, L. and Lupanovic, S. 1965. A contribution to the knowledge of biology of *Pagellus erythrinus* L. in the middle Adriatic. Rapp. P.V. Réun. CIESM 18: 195-200.

Shepherd, G. and Grimes, C.B. 1983. Geographic and historic variations in growth of weakfish, *Cynoscion regalis*, in the Middle Atlantic Bight. Fish. Bull. 81: 803-813.

Somarakis, S. and Machias, A. 2002. Age, growth and bathymetric distribution of red pandora (*Pagellus erythrinus*) on the Cretan shelf (eastern Mediterranean). J. Mar. Biol. Ass. U.K. 82: 149-160.

Sparre, P. and Venema, S.C. 1998. Introduction to tropical fish stock assessment - Part 1: Manual, 306/1, Rev. 2. FAO Fish. Tech. Pap. Rome.

Stergiou, K.I. and Moutopoulos, D.K. 2001. A review of length-weight relationships of fishes from Greek marine waters. Naga ICLARM Q. 24: 23-39.

Stergiou, K.I., Christou, E.D., Georgopoulous, D., Zenetos, A. and Souvermezoglou, C. 1997. The Hellenic seas: physics, chemistry, biology and fisheries. In: Oceanography and marine biology: an annual review (ed. A.D. Ansell, R.N. Gibson and M. Barnes), UCL Press, pp. 415-538.

Tosunoğlu, Z., Akyol, O., Metin, G., Tokaç, A. and Ünsal, S. 1997. The study on the population characteristics of three sparid species in the Gülbahçe Bay. E.U. J. Fish. & Aquat. Sci. 14: 127-143.

Turkstat, 2007. The fishery statistics of Turkey. Prime Ministry Republic of Turkey Turkish Statistical Institute, Ankara.

Ünsal, N. 1984. Determination of the sparids (Sparidae) of the Sea of Marmara and researches on the biology of two dominant species, pandora (*Pagellus erythrinus*) and annular bream (*Diplodus annularis*). Ist. Univ. Fac. of Sci. Periodical Serial B 49: 99-118.

Valdés, P., García-Alcázar, A., Abdel, I., Arızcun, M., Suárez, C. and Abellán, E. 2004. Seasonal changes on gonadosomatic index and maturation stages in common pandora *Pagellus erythrinus* (L.). Aquaculture International 12: 333-343.

Vassilopoulou, V., Mytilineou C. and Papaconstantinou C. 1986. Preliminary biological data on the red pandora (*Pagellus erythrinus* L. 1758) in the Greek seas. FAO Fish. Rep. 361: 107-112.