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Age and growth of adult gilthead seabream (*Sparus aurata* L.) in the Aegean Sea

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Age and growth of adult gilthead seabream, Sparus aurata *were determined from 332 specimens (total N = 476), collected from purse-seiners, in the south-eastern Aegean Sea from November 2006 to January 2007. The fork length and body wet weight ranged from 26.5 to 51.5 cm (mean: 36.6 ± 0.18) and from 375 to 2600 g (mean: 1009.2 ± 14.16), respectively. Age groups were varied between 2 and 7. Growth parameters were estimated as* $L_\infty = 64.97 \pm 12.93$ *cm,* $K = 0.14 \pm 0.07$ *year*$^{-1}$, $t_o = -2.47 \pm 1.09$ *year*$^{-1}$, *and index of phi-prime was* $\Phi' = 2.772 \pm 0.51$. *The length–weight relationship equation of all fish was calculated as* $W = 0.0515 \times L^{2.737}$ ($r^2 = 0.95$). *The mean condition factor was estimated as 2.058. Mortalities (M, F and Z) and exploitation rate (E) of gilthead seabream from the Aegean Sea were 0.34 year*$^{-1}$, *0.77 year*$^{-1}$, *1.11 year*$^{-1}$*and 0.69 year*$^{-1}$, *respectively. The result of E indicated that the population was overexploited.*

Keywords: gilthead seabream, *Sparus aurata*, age and growth, mortality, Aegean Sea

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INTRODUCTION

Gilthead seabream, *Sparus aurata* Linnaeus 1758, inhabits *Posidonia* beds and sandy bottoms commonly to depths of about 30 m, but adults may occur to 150 m depth. The euryhaline gilthead seabream are sedentary fish, either solitary or in small aggregations, and they often occur in brackish waters of coastal lagoons and estuaries in spring (Bauchot & Hureau, 1990). Gilthead seabream is common throughout the Mediterranean Sea, but very rare in the Black Sea. It is also present in the eastern part of the Atlantic Ocean, from Britain to Cape Verde and the Canaries (Bauchot & Hureau, 1986).

Gilthead seabreams are captured with traditional bottom trawl nets, coastal purse-seines, bottom set longline and hand lines, and are regularly present to the markets in Turkey. In 2008, the total marine capture and aquaculture productions of gilthead seabream were 1526 t and 31,670 t, respectively, i.e. the captured fish are a little bit more than 4.8% of aquaculture production (TUIK, 2009).

In spite of the fact that culture of the gilthead seabream has benefited from considerable research effort, there is a lack of research on its ecology (i.e. age, growth, reproduction, feeding habits, etc.) in natural environments in the Mediterranean (Lasserre & Labourg, 1974; Arnal *et al.*, 1976; Lasserre, 1976; Kraljevic & Dulcic, 1997; Chaoui *et al.*, 2006). Furthermore, no information is currently available on the biology and ecology of this species in the Aegean Sea.

This paper presents some basic biological information such as age, growth, length–weight relationship, mortality rates for the adult component of the species, caught during spawning migration in the south-eastern Aegean Sea.

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MATERIALS AND METHODS

Gilthead seabream were collected from four coastal purse-seiners (24–26 m LOA, 2 × 400 hp engine) by using purse-seine net (total length 1000 m and stretched mesh size 36 mm) in winter months between November 2006 and January 2007 off Güllük Bay at a depth of about 60 m (Figure 1). Though the purse-seiners usually catch sardines and/or anchovy, some of them are concentrated to catch mature gilthead seabream during their spawning migration to provide the mature fish for the hatcheries in the same area.

Lively caught fish were transferred to the airing tanks on the deck. They were then transported ashore to the fish farm. A total of 476 fish were randomly chosen and bathed in an anaesthetic, 2-phenoxyethanol solution. Anaesthetized fish were measured (fork length (FL) to the nearest ±0.5 mm) and weighed (total weight, to the nearest ±5 g).

Ageing was done by scale reading. Scale samples (from 6 to 8 scales), taken from 332 fish, were removed from the base of the pectoral fin and from the flanks below the dorsal fin. They were cleaned in 5% sodium peroxide and then immersed in glycerol in a black Petri dish, and annuli, defined as opaque and hyaline zones were counted by using a binocular microscope (10×) (Figure 2). Bauchot & Hureau (1986) reported that the spawning season of the gilthead seabream ranges from October to December. So, this period was assumed as birth date.

The length–weight relationship (LWR) of all fish was estimated based on power regression as $W = aL^b$, where W is the weight (g), L is the fork length (cm), *a* and *b* are constants. The Fulton's condition factor (*CF*) for all fish was calculated according to the equation $CF = (W/FL^3) \times 100$.

Non-seasonal growth parameters (L_∞, K, t_o) were estimated with the von Bertalanffy growth (VBG) formula in the FISAT (FAO–ICLARM Stock Assessment Tools) computer program (Gayanilo *et al.*, 1994) using individual

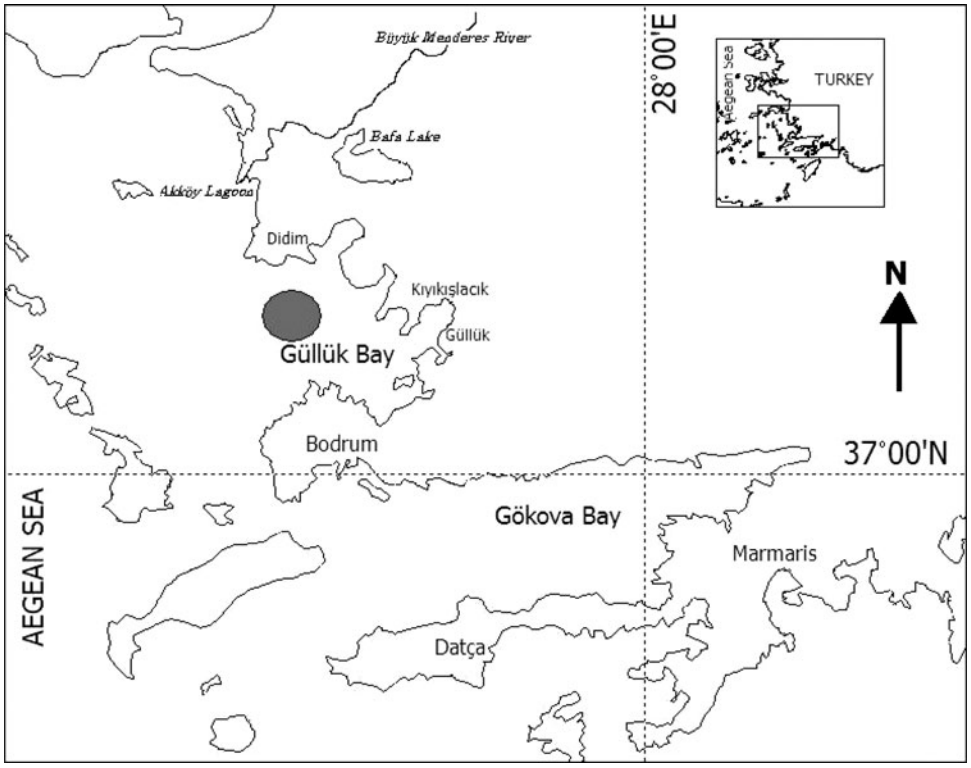

Fig. 1. Sampling area. The circle indicates the fishing ground.

lengths-at-age. The von Bertalanffy growth equation for length, $L_t = L_\infty\ [1 - e^{-K(t-t_o)}]$, where L_∞ is the asymptotic length, K the growth curve parameter, and t_o is the theoretical age when fish length would have been zero, was applied.

Overall growth performance was estimated by the index Φ' (phi-prime test) (Pauly & Munro, 1984), $\Phi' = \log K + 2\log L_\infty$.

Natural mortality (M) of gilthead seabream was computed using Pauly's (1980) multiple regression formula: $\log M = -0.0066 - 0.279 * \log L_\infty + 0.6543 * \log K + 0.4634 * \log T$, where M is natural mortality in a given stock, and the value of T is the mean annual temperature at the surface (in °C). The average annual temperature (T = 20°C) for Güllük Bay was taken from Özfuçucu *et al.* (2000). Total mortality (Z) was estimated as the linearized catch curve based on age composition data (Sparre & Venema, 1992). Fishing mortality (F) can be estimated from F = Z – M. Once values of F and M are available, an exploitation ratio (E) can be computed from E = F/Z. The exploitation ratio can be used to assess if a stock is overfished or not, on the assumption that the optimal value of E (E_{opt}) is about equal to 0.5 (Pauly, 1980).

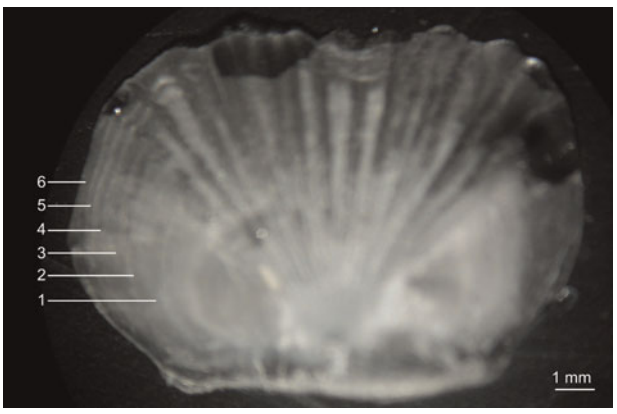

Fig. 2. Scale of gilthead seabream at 6 years old (45 cm fork length).

RESULTS

Length and weight–frequency distribution

The length–frequency distribution of all fish is shown in Figure 3. The length and weight of specimens ranged from 26.5 to 51.5 cm and from 375 to 2600 g, respectively (Table 1).

Age and growth

Age groups were varied between 2 and 7, and mean fork lengths (and mean wet weight) were 29.5 cm (497.5 ± 7.6 g), 35.3 ± 0.15 cm (881.9 ± 9.7 g), 39.3 ± 0.14 cm (1200.8 ± 12.0 g), 42.2 ± 0.19 cm (1467.8 ± 24.2 g), 45.6 ± 0.43 cm (1878.6 ± 61.8 g) and 51.5 cm (2600.0 g),

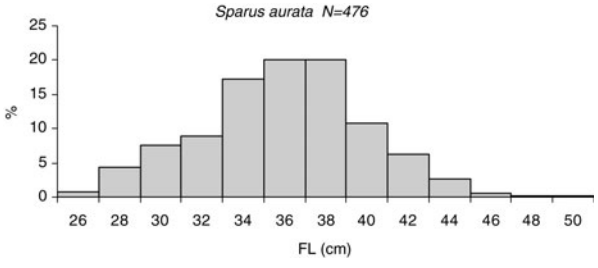

Fig. 3. Length–frequency distribution for the gilthead seabream in the Aegean Sea.

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Table 1. Range, mean with standard error (SE), median and mode of fork length (cm) and body weight (g) for gilthead seabream from the Aegean Sea.

	Length (cm)	Weight (g)
N	476	476
Range	26.5–51.5	375–2600
Mean (±SE)	36.6 ± 0.18	1009.2 ± 14.16
Median	36.8	970
Mode	38.0	940

respectively (Table 2). Modal age was 3 years (55.1%). The observed lengths of specimens assigned to each group were used to fit the VBG formula (Figure 4). Growth parameters with SE were found as $L_\infty = 64.97 \pm 12.93$ cm, $K = 0.14 \pm 0.07$ year^{-1}, $t_o = -2.47 \pm 1.09$ year^{-1}, and index of phi-prime was $\Phi' = 2.772 \pm 0.51$.

There were no statistical differences between the observed (obs.) and calculated (calc.) mean lengths in all age groups (t-test, $P > 0.05$) (Table 3).

Length–weight relationship

The LWR equation calculated was: $W = 0.0515 \times L^{2.737}$ ($r^2 = 0.95$) (Figure 5). The mean *CF* of all fish was estimated as 2.058.

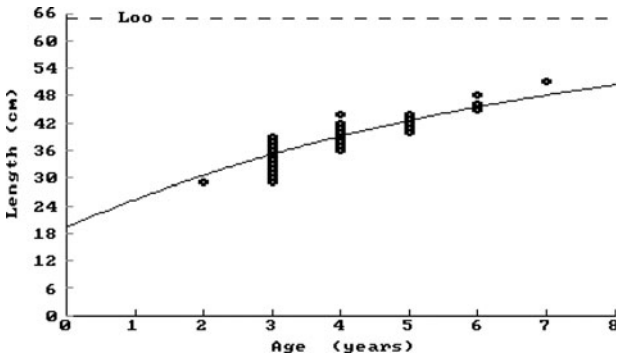

Fig. 4. Von Bertalanffy growth curve fitted by length-at-age for gilthead seabream.

Table 3. Observed and calculated mean lengths (fork length, cm) of gilthead seabream for each age group.

Length parameter	Value per age group (year)						
	1	2	3	4	5	6	7
$L_{obs.}$	–	29.5	35.3	39.3	42.2	45.6	51.5
$L_{calc.}$	25.0	30.2	34.8	38.7	42.1	45.1	47.7

Table 2. Age–length key for the gilthead seabream in the Aegean Sea based on scale reading.

Length group (cm)	Age (years)						Total N
	2	3	4	5	6	7	
29	2	2					4
30		3					3
31		8					8
32		4					4
33		15					15
34		31					31
35		31					31
36		45	4				49
37		21	9				30
38		22	25				47
39		1	30				31
40			21	1			22
41			14	8			22
42			4	12			16
43				5			5
44			2	4			6
45					5		5
46					1		1
47							
48					1		1
49							
50							
51						1	1
Total N	2	183	109	30	7	1	332
%	0.6	55.1	32.8	9.1	2.1	0.3	100.0
Mean L_t (cm)	29.5	35.3	39.3	42.2	45.6	51.5	
±SE	–	0.15	0.14	0.19	0.43	–	
Mean W_t (g)	497.5	881.9	1200.8	1467.8	1878.6	2600.0	
±SE	7.6	9.7	12.0	24.2	61.8	–	

SE, standard error.

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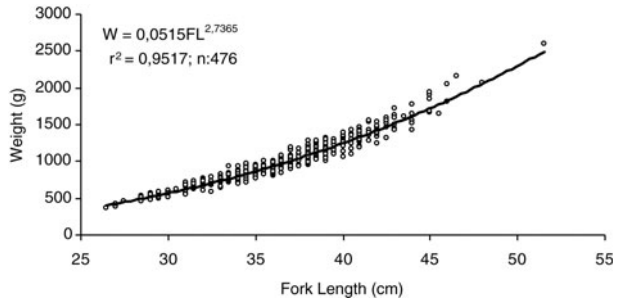

Fig. 5. Length–weight relationship for the gilthead seabream.

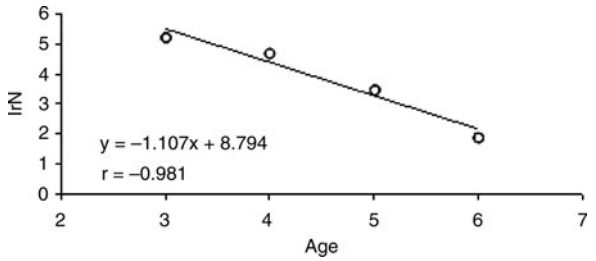

Fig. 6. Total mortality of gilthead seabream from linearized catch curve based on age composition data.

Mortality rates

Mortalities (M, F and Z) and exploitation rate (E) of gilthead seabream from the Aegean Sea were 0.34 year^{-1}, 0.77 year^{-1}, 1.11 year^{-1} and 0.69 year^{-1}, respectively. Total mortality rate (Z) was calculated from linearized catch curve based on age composition data (Figure 6).

DISCUSSION

Adult gilthead seabream were caught by purse-seiners during the spawning migration from November to early January in Güllük Bay. This type of fishery has only been carried out in this area for about 5 years in order to supply mature fish to the hatchery.

Juvenile individuals of this species are more common in lagoons, as reported by Lasserre (1976) in the Arcachon basin (France), by Kraljevic & Dulcic (1997) in Mirna Estuary in the Adriatic Sea, by Perçin (2005) in Homa lagoon in the Aegean Sea (Turkey) and by Chaoui *et al.* (2006) in Mellah lagoon in north-eastern Algeria. In this study, the majority of fish were adults, suggesting that sampling occurred on the spawning migration within Güllük Bay, and that juveniles seek the nearby Akköy Lagoon and Büyük Menderes estuary environments as nursery areas.

Compared to other areas of the Mediterranean Sea and Atlantic Ocean where gilthead seabream are found, the growth rate in the Aegean Sea is slower than all areas except Mirna. The fastest growth rate was reported for the Mellah lagoon population due to very favourable thermal conditions (temperatures recorded in this area were higher than 15°C (15–30°C) during eight months of the year) (Chaoui *et al.*, 2006). In general, the western part of the Mediterranean encompasses faster growth populations than the eastern part. Our results ($L_\infty = 64.97$ cm) support previous estimates for gilthead seabream in the area of an intermediate asymptotic length (Table 4). Our estimate of K is also within the range of those of other populations (Table 4). However, the estimation of $t_o = -2.47$ in this study may indicate that the smaller gilthead seabreams were not sampled adequately (i.e. the smallest size of the gilthead seabream was only 26.5 cm FL). The differences between sizes-at-ages may arise from different localities such as lagoon, estuary and open sea, and from various hydrographical conditions.

The b coefficient of the LWR ($b = 2.737$) indicates allometric growth. This value is close to the Thau's pond and Graveyron, France (Lasserre & Labourg, 1974; Lasserre, 1976). The low value of b is possibly explained by the winter catches of specimens which had already spawned (after the November–December period). The mean CF (2.058) of gilthead seabream in the Aegean Sea is higher than the Mirna estuary due to the younger population there, i.e. about 72% of gilthead seabream consisted of age 1 fish in Mirna.

The gilthead seabream is a long lived species, and maximum reported age and size are 12 years and 57.5 cm (2500 g) (Kraljevic & Dulcic, 1997). The observed maximum length for the Mediterranean is 70 cm total length by Bauchot & Hureau (1986). So, the absence of larger, older fish in our samples may suggest heavy fishing pressure on gilthead seabream in the Aegean Sea. Although all sampled fish were bigger than the minimum landing size (MLS) for gilthead seabream, 15 cm in the Turkish Fishery Regulation Circular (TFRC), the estimate of fishing mortality (F = 0.77) is much higher than natural mortality (M = 0.34), and the

Table 4. Growth parameters (L_∞, K and t_o) of gilthead seabream from different localities (adapted from Chaoui *et al.*, 2006).

Locality	Age	N	L_∞	K	t_o	$\Phi'^{(*)}$	Reference
Graveyron (France)	1–4	126	42.29	0.46	−0.45	2.91	Lasserre & Labourg (1974)
Thau (France)	1–4	713	62.02	0.22	−0.77	2.93	Lasserre & Labourg (1974)
Sagura (Spain)	2–6	135	53.00	0.32	–	2.95	Arnal *et al.* (1976)
Graveyron (France)	2–5	94	53.48	0.26	−1.34	2.88	Lasserre (1976)
Adour (France)	2–5	79	56.17	0.27	−0.41	2.92	Lasserre (1976)
Thau (France)	1–4	383	57.66	0.27	−0.54	2.96	Lasserre (1976)
Ebre (Spain)	1–7	611	62.19	0.17	−0.53	2.82	Suau & Lopez (1976)
Cadiz (Spain)	1–7	1775	84.55	0.13	−1.59	2.97	Arias (1980)
Mirna (Croatia)	1–12	314	59.76	0.15	−1.71	2.74	Kraljevic & Dulcic (1997)
Mellah lagoon (Algeria)	1–7	370	55.33	0.51	−0.28	3.20	Chaoui *et al.* (2006)
Güllük Bay (Turkey)	2–7	332	64.97	0.14	−2.47	2.77	Present study

(*), phi-prime test, this parameter was calculated from data for other studies.

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exploitation rate (E = 0.69) suggests overfishing. Chaoui *et al.* (2006) stated that the onset of sexual maturity for gilthead seabream was reached at 32.6 cm, at an average age of 18 months. Thus, the relatively low MLS of gilthead seabream in TFRC does not appear effective in allowing fish to spawn at least once. Kraljevic & Dulcic (1997) reported natural mortality (M = 0.32) almost equal to that of this study. The low natural mortality was associated by the authors with biological features (big, slow-growing and long-lived species), as well as behaviour and ecology of this fish.

In conclusion, adult gilthead seabream represent an important fishery for hatcheries in the south-eastern Aegean region, and this fishery is likely to increase due to demand by fish farms. The resource may not be sustainable, if some regulations (e.g. closed area and/or season, higher MLS, size selectivity, etc.) are not implemented. Further investigations are necessary to quantify the impact of the existing regulations on the population dynamics and recruitment patterns of gilthead seabream in the region.

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