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AGE, GROWTH AND MORTALITY OF THE COMBER, *SERRANUS CABRILLA* (SERRANIDAE) IN THE EDREMIT BAY (NW AEGEAN SEA, TURKEY)

by

Hatice TORCU-KOC (1), Dilek TÜRKER-CAKIR (2) & Jakov DULČIĆ (3)

ABSTRACT. - Age, growth and mortality of comber, *Serranus cabrilla* (L., 1785) were determined from 595 specimens collected on the northwestern Aegean coasts of Turkey from September 1997 to September 1998. Fork length ranged from 8.6 to 22.3 cm, while weight varied between 10.5 and 163.7 g. The von Bertalanffy growth equation was fitted on the basis of mean length-at-age data resulting in parameters values of $L\infty$ = 33.6 cm (S.E. = 0.46), K = 0.111/y (S.E. = 0.03), t_0 = -3.17 (S.E. = 0.030). Weight increased allometrically for both sexes together with b = 2.67 (S.E. = 0.226). The comber is a relatively short-lived species. The oldest male and female were estimated to be 4 years old. The total (Z) and natural (M) mortality were 0.49 and 0.32 per year, respectively. The exploitation ratio E = 0.35 indicated that the population was slightly exploited. The sex ratio was skewed in favour of females (1.26:1). The monthly values of gonadosomatic index (GSI) of females indicated that spawning occured mainly in April and May.

RÉSUMÉ. - Âge, croissance et mortalité du serran petite-chèvre, *Serranus cabrilla* (Serranidae), dans la baie d'Edremit (Mer Égée, Turquie).

L'âge, la croissance et la mortalité du serran petite-chèvre, *Serranus cabrilla* (L., 1785) ont été determinés à partir d'échantillons (N = 595) collectés sur les côtes turques du nord-ouest de la Mer Egée, entre septembre 1997 et septembre 1998. La longueur à la fourche a varié entre 8,6 et 22,3 cm, tandis que le poids a varié entre 10,5 et 163,7 g. L'équation de croissance de von Bertalanffy, basée sur les paramètres de longueur moyennes par âge, a donné les résultats de $L\infty$ = 33,6 cm (S.E. = 0,46), K = 0,111/an (S.E. = 0,03), et t_0 = -3,17 (S.E. = 0,030). Le poids s'accroît de façon allométrique pour les deux sexes avec une valeur b = 2,67 (S.E. = 0,226). Ce serran a une durée de vie assez courte. Les individus les plus vieux, mâles et femelles, ont été estimés à un âge de 4 ans. Les mortalités totale (Z) et naturelle (M) ont été de 0,49 et 0,32 par an, respectivement. Le taux d'exploitation E = 0,35 indique que la population n'est que faiblement exploitée. La sex ratio est en faveur des femelles (1,26:1). Les valeurs mensuelles de l'indice gonadosomatique (GSI) des femelles ont suggéré que la ponte a lieu principalement entre avril et mai.

Key words. - Serranidae - *Serranus cabrilla* - MED - Edremit Bay - NW Aegean Sea - Age - Growth - Mortality.

The comber, *Serranus cabrilla* (Linnaeus, 1785) is a commercial serranid species with a distribution ranging from the north Atlantic Sea, up to the North Sea, to the Mediterranean Sea (Politou and Papaconstantinou, 1995). It is found in depths up to 500 m, on rocks, *Posidonia oceanica* beds, sandy and muddy bottoms (Jardas, 1996). It is one of the main species captured by trawlers fishing in the Aegean Sea along the Turkish coast. *S. cabrilla* is the most abundant comber among the three congeners found in Turkish Seas (*S. cabrilla*, *S. scriba* and *S. hepatus*) (Aksiray, 1954; 1987).

In spite of its wide distribution and commercial importance, studies on the dynamics of comber stocks are limited (Papaconstantinou *et al*., 1994; Politou and Papaconstantinou, 1995; Tserpes and Tsimenidis, 2001). The total landings of comber in Turkey are unknown, as the catches of the small coastal boats that in many cases target comber are not monitored by the National Statistical Sevice of Turkey. Accordingly, the exploitation status of the stocks is unknown.

Papaconstantinou *et al*. (1994) presented growth parameters and the fork length at first maturation of comber for the north Aegean Sea (Greece). The growth parameters and age composition of comber were presented for the Northern Greece (Politou and Papaconstantinou, 1995). Petrakis and Stergiou (1995) and Stergiou and Motopoulos (2001) presented data on the length-weight relationship for comber from Greek waters, while Gonçalves *et al*. (1997) examined this relationship for comber from the south-west coast of Portugal. Stergiou (1997) discussed spawning seasonality of comber from the English channel and Mediterranean Sea. Tserpes and Tsimenidis (2001) studied age, growth and mortality of comber from the Cretan shelf.

Published literature on the biology and ecology of this species from Turkish Seas are very limited. Torcu *et al*. (1998) presented some preliminary data on growth patterns

(1) University of Balıkesir, Faculty of Science and Arts, Department of Biology, 10100, Balikesir, TURKEY.

(2) University of Ege, Faculty of Water Products and Fisheries, Bornova / Izmir, TURKEY.

(3) Institute of Oceanography and Fisheries, P.O. BOX 500, Šetalište Ivana Meštrovića 63, 21000 Split, CROATIA. [dulcic@izor.hr]

of comber from the Gulf of Edremit, but little information is currently available on mortality, length-weight relationship, condition factor and gonadosomatic index.

The objective of this study was to obtain updated data on age and growth and first-time data on length-weight relationship, condition factor, gonadosomatic index and mortality of comber collected from the Bay of Edremit (north Aegean coast of Turkey).

MATERIAL AND METHODS

A total of 595 specimens were collected with trawl at monthly intervals, during the period from September 1997 to September 1998. Sampling location was in Edremit Bay (North Aegean coast of Turkey) between Altinoluk and Bozburun (Fig. 1). This bay occupies an area of 34.5 km from east to west, 25.5 km. from north to South (Northern Aegean Sea) between 39°17' and 39°34'N, 26°57' and 26°34'E. Trawling was done only during daytime at depths ranging from 45 to 60 m. Duration of hauls was about 2 hours and the speed was 2 miles per hour. The trawl was equipped with a 22 mm stretched mesh size at the cod-end.

The fork length (FL) of all fish was measured to the nearest 0.5 cm and weighed (gross, somatic and gonad weight) to the nearest 0.01g. The gonads were macroscopically examined to determine the sex and reproductive stage. The five-point maturity scale was a simplified version of Pinto and Andreu (1957) maturity scale (stage I-virgin or resting; II-maturing stage; III-prematuring stage; IV-spawning; V-post spawning stage).

Otolith pairs were removed, cleaned and stored dry in paper envelopes. All 595 *S. cabrilla* specimens were used for the age and growth analysis. Ages were determined using the methods of Chugunova (1963) and Tserpes and Tsimenidis (2001). Whole otoliths were viewed under a binocular microscope at 20 times magnification using reflected light and a dark background. The number of opaque zones (summer rings, appearing dark under reflected light) and the presence of marginal translucent zone (winter rings, appearing bright under reflected light) was checked by two readers. To avoid subjectivity effect on age estimations, as much as possible, there was an interval of 1 month between readings. Translucent bands that continued around the entire circumference of the otolith were considered to be annuli and the total number of these bands was recorded as the age. Age-classes were assigned based on the number of annuli and the month the fish was collected. Date of birth was set at April according to our results. As *Serranus cabrilla* is synchronously hermaphroditic (ovarian tissue development is asynchronous, testicular tissue consists of continuous spermatogonia) (Garcia-Diaz *et al*., 1997), age analysis was carried out independently of sex.

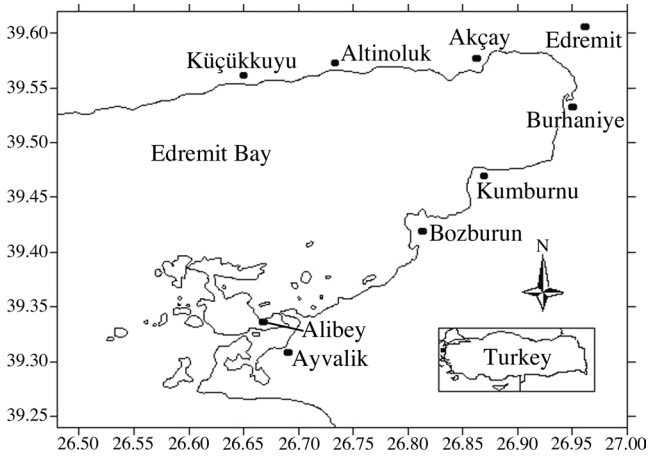

Figure 1. - Sampling area in Edremit Bay, in the Northern Aegean Sea off Turkey.

The length-weight relationship was described by the equation: $W = aFL^b$, where W is the weight in grams, FL the fork length in cm, *b* the growth exponent or length-weight factor (slope), and *a* is a constant (y-intercept). The hypothesis of isometric growth (Ricker, 1975) was tested using a t-test. The Fulton's condition factor (CF) was calculated as $CF = W \times 100 / FL^3$ to assess the maturity and condition of the specimens (Dulčić *et al*., 2000). Non-linear regression was used to estimate the growth parameters L_∞, K and t_0 in the von Bertalanffy equation. This procedure uses an iterative search algorithm in an attempt to determine the estimates that minimize the residuals sum of squares, $FL_t = FL_\infty (1-e^{-K(t-to)})$ where FL_t is the fork length at age t, L_∞ is the asymptotic or maximum fork length that an average fish would achieve if it continued to live and grow, K is the body growth coefficient which determines how fast the fish approaches L_∞ and t_0 is the hypothetical age for $FL_t = 0$.

Spawning period was determined by analyzing the monthly percentages of mature individuals (on the basis of macroscopic classification) and the mean gonadosomatic index (GSI) over the one-year study period. Only those specimens with a size larger than the length of first maturity were considered, thus avoiding possible size-dependent biases by reason of the uneven length distribution in monthly samples. Individual GSI was calculated by the equation: GSI = (GW / SW) x 100, where GSI is the gonadosomatic index, GW is gonad weight and SW is somatic weight (body weight minus gonad weight). Sex ratio was analysed monthly (on the basis of macroscopic classification). Deviations from 1:1 null hypothesis were statistically tested by Chi-square (χ^2) analysis (Sokal and Rohlf, 1981).

Natural mortality (M) was estimated using the empirical formula proposed by Pauly (1980): log (M) = -0.0066-0.2791 x log (FL_∞) + 0.65431 log (K) + 0.46341 log (T), where FL_∞ and K are parameters from the von Bertalanffy

equation, and T is the mean environmental temperature at the study area at the depth between 45 and 60 m (18°C). The estimation of fishing mortality was F = Z - M, where Z is the total instantaneous mortality rate. The total instantaneous mortality rate (Z) was calculated from the length-converted catch curve (Pauly, 1983) using FiSAT (Gayanilo *et al*., 1994). Exploitation ratio was calculated by the equation: E = F / Z (Pauly, 1980).

RESULTS

Length-weight relationship

Fork length ranged from 8.6 to 22.3 cm (N = 595) (Fig. 2) and the weight from 10.5 and 163.7 g. We calculated the weight-length equation for all individuals: $W = 0.311L^{2.67}$ ($R^2 = 0.88$) (Fig. 3).Weight increased slower then the allometric rate of 3.0 since our slope value, b = 2.67 (S.E. = 9.059) was significantly different from 3.0 ($p > 0.05$). We calculated the mean condition factor for all individuals: CF = 1.281 (S.D. = 0.224).

Age and growth

The results of reading otoliths are provided in table I. For the estimation of growth in length, the sexes were not considered separately because of synchronously hermaphroditism (Garcia-Diaz *et al*., 1997). The von Bertalanffy growth equation was estimated as $L_\infty = 33.55$ (S.E. = 0.461), K = 0.111/y (S.E. = 0.029), and $t_0 = -3.17$ (S.E. = 0.030) (Fig. 4). The value of L_∞ is higher than maximum observed length.

Mortality

The total mortality (Z) was found to be 0.49/year. Inserting in Pauly's (1980) equation the growth parameters

Table I. - Age-length data for comber in the Edremit Bay, Turkey (N = 595).

Length groups (cm)	Age (years) from whole otoliths				Total
	1	2	3	4	
8.5	2				2
9.0	12				12
9.5	5				5
10.0	1	1			2
10.5	1	1			2
11.0	2	1			3
11.5	12	4			16
12.0	12	5	1		18
12.5	11	3	2		16
13.0	13	21	2		36
13.5	7	36	6		49
14.0	13	33	13		59
14.5	3	46	19	1	69
15.0	3	33	32	2	70
15.5	2	22	17	1	42
16.0	1	14	26		41
16.5	1	10	27	1	39
17.0		6	26	3	35
17.5		3	18	2	23
18.0		1	8	7	16
18.5		1	10	2	13
19.0			7	5	12
19.5			2	4	6
20.0			2	1	3
20.5			1	1	2
21.0					
21.5			1	1	2
22.0				2	2
Total	101	241	220	33	595
Percentage	16.96	40.51	36.98	5.55	100
Mean FL (cm)	12.28	14.60	16.37	18.55	
S.D.	1.86	1.22	1.53	1.78	
Mean W_t (g)	26.87	40.89	55.55	86.06	
S.D.	11.01	10.94	18.12	27.43	

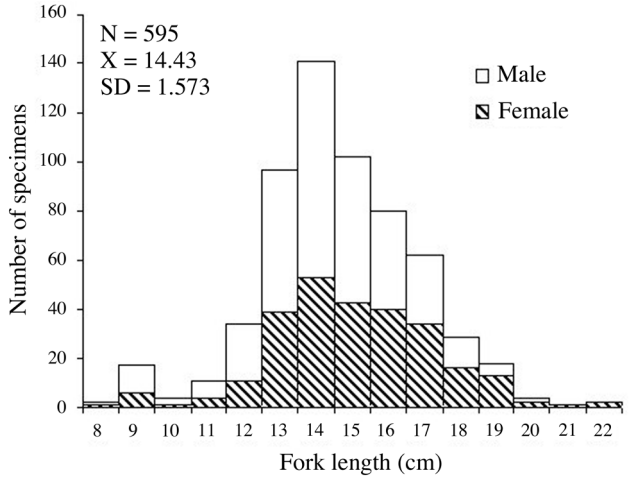

Figure 2. - Length frequency distribution for comber from Edremit Bay.

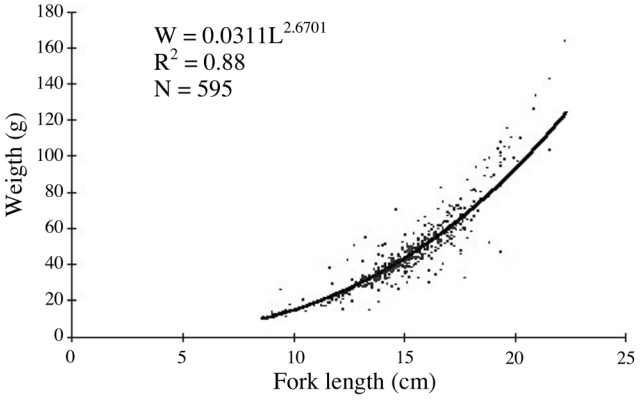

Figure 3. - Fork length-weight relationship of all comber [N = 595] from Edremit Bay.

Table II. - Numbers of female and male comber per sampling month and results of chi-square (χ^2) analysis.

Month/year	10/97	11/97	12/97	1/98	2/98	3/98	4/98	5/98	6/98	7/98	8/98	9/98	10/98
No. of females	12	11	13	10	27	37	26	12	17	27	42	15	13
No. of males	10	13	21	15	37	37	1	20	36	55	18	49	21
Female:male ratio	1.2:1	0.85:1	0.62:1	0.66:1	0.73:1	1:1	2.6:1	0.6:1	0.46:1	0.48:1	2.33:1	0.3:1	0.62:1
Female:male significance	No	No	No	No	No	No	Yes	No	No	No	Yes	No	No
Different from 1:1 (P)	>0.001	>0.001	>0.001	>0.001	>0.001	>0.001	<0.001	>0.001	>0.001	>0.001	<0.001	>0.001	>0.001
χ^2	0.73	0.1	0.48	0.15	0.06	1.16	29.4	0.51	2.76	4.01	16.66	6.46	0.48

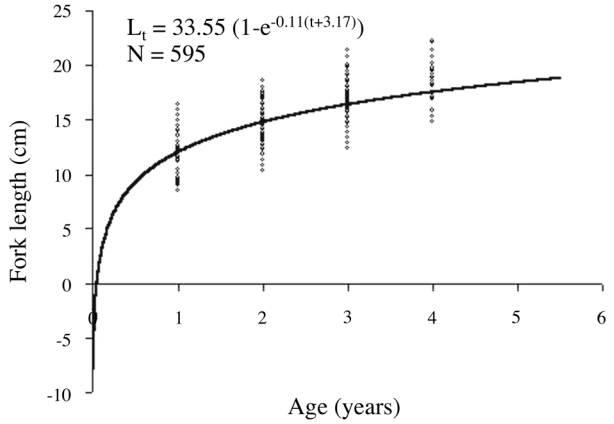

Figure 4. - Von Bertalanffy's growth curves fitted to length at age values (raw data) for comber from Edremit Bay.

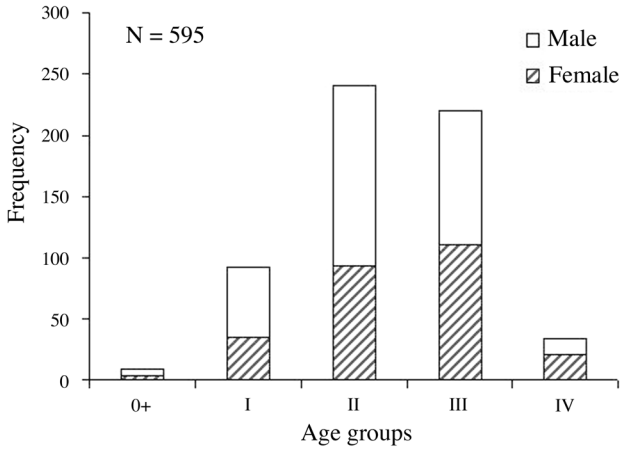

Figure 5. - Sex-specific age frequencies.

L_∞, K and the annual mean temperature of the study area (T = 18°C) M was 0.32/year. Accordingly, the fishing mortality (F) was calculated as F = 0.17/year, the exploitation rate was computed as E = 0.35, indicating that the stock in Edremit Bay, is being lightly exploited.

Sex ratio and reproduction

The overall female: male ratio (1.26:1) (on the basis of macroscopic classification) was significantly different from 1:1 ratio ($\chi^2 = 62.96$, $p < 0.01$). The female and male ratio and corresponding chi-square (χ^2) values per month are presented in table II and figure 5. All monthly samples contained significantly more male fish.

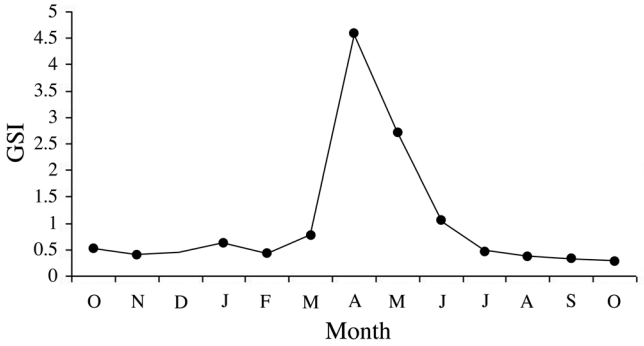

Figure 6. - The monthly gonadosomatic index (GSI) of comber, October 1997-1998 from Edremit Bay.

Gonadosomatic index and length at first maturity

For the whole period, length at first maturity (L_{50}) was estimated as $L_{50} = 15.0 \pm 1.86$ cm for females. The GSI results revealed that the reproduction occured between March and May, indicating a peak in April when the GSI reached its highest level (Fig. 6).

DISCUSSION

A theoretical maximum length of 33.55 cm is not realistic because of the largest specimen sampled during the survey was 22.3 cm. The maximum recorded lengths prior to our study were: 32.0 cm FL (JICA, 1993) 25.8 cm (Papaconstantinou *et al*., 1994), 18.2 cm TL (Petrakis and Stergiou, 1995), 21.7 cm FL (Politou and Papaconstantinou, 1995), 30.2 cm TL (Gonçalves *et al*., 1997) and 19.9 cm TL on the Cretan Shelf (Tserpes and Tsimenidis, 2001) (Tab. III). Weight-at-age estimates were more variable as a measure of growth length estimates. This variation may be due to different stages in ontogenetic development, as well as differences in condition, length, age, sex, and gonad maturity (Ricker, 1975). Geographic location and some environmental condi-

Table III. - Age structure, parameters of the length-weight relationship (a, *b*) and the growth ($L\infty$, k, t_o) of *Serranus cabrilla* in this study and in previous studies (- indicates absence of data). a: Using total length; b: Using fork length; 1A: Preliminary study.

Authors	Study area	Max. age (years)	N	a	*b*	R^2	L° (cm)	K	t_o	Length range (cm)
Bouain (1981, 1983)	Tunisia	9	-	-	-	-	-	-	-	-
Bauchot (1987)	-	4	-	-	-	-	-	-	-	-
Magnussion and Magnussion (1987)(a)	Cape Verde Islands	-	57	0.0252	2.79	-	-	-	-	4.0-36.0
JICA (1993)(b)	Turkish Seas	5	554	$4.48*10^{-5}$	3.02	0.95	-	-	-	6.0-32.0
Papaconstantinou *et al*. (1994)	-	-	-	-	-	-	25.8	0.3	-0.307	-
Politou and Papaconstantinou (1995)(b)	N. Greece	8	665	-	2.75	0.90	238.1	0.3	-0.367	-
Petrakis and Stergiou (1995)(a)	-	-	54	0.0220	2.92	0.96	-	-	-	7.7-18.2
Merella *et al*. (1997)(a)	Balear Islands	-	23	0.0160	2.82	0.99	-	-	-	-
Gonçalves *et al*. (1997)(a)	Portugal	-	171	0.0000733	2.661	0.90	-	-	-	12.0-30.2
Torcu *et al*. (1998)(b)(1A)	Edremit Bay	4	243	0.0353	2.61	0.75	-	-	-	8.6-22.2
Present study (b)	Edremit Bay	4	595	0.0311	2.67	0.88	33.55	0.24	-0.11	8.6-22.3

tions, such as date and time of capture, stomach fullness, disease and parasite loads (Bagenal and Tesch, 1978) can also affect weight-at-age estimates.

Our value of b = 2.67 is similar to that estimated by Torcu *et al*. (1998) (b = 2.62) for Edremit Bay, by Magnussion and Magnussion (b = 2.79) for Cape Verde Islands, by Papaconstantinou *et al*. (1994) (b = 2.73) and by Petrakis and Stergiou (1995) (b = 2.93) for Greek waters and by Merella *et al*. (1997) (b = 2.82) for Balearic Islands. It is identical to that calculated (b = 2.66) by Gonçalves *et al*. (1997) for Portugese waters, but differs from that estimated (b = 3.00) by Motopoulos and Stergiou (2002) from Cyclades (Greek waters) and (b = 3.04) by Abdallah (2002) off Alexandria (Egypt waters) (Tab. III). Our value could be explained by the dominance, in the total catch, of individuals already spawned (after the March-July period). Changes in fish shape, physiological changes, hydrological environmental conditions, different food availability during life and biological span, growth increment or break in growth can all affect the growth exponent b (Frost, 1945).

The comber is a short-lived species in the Edremit Bay. The maximum observed life span was 4 years for both sexes. This is probably a result of synchronously hermaphroditism of the species (Garcia-Diaz *et al*., 1997). Torcu *et al*. (1998) found the maximum age to be 4 years for the comber in the same geographic area (between October 1997 and March, 1998), while JICA (1993) stated the maximum age to be 5 years. Bauchot (1987) noted that 18 cm fish were 4 years old, while Bouain (1981) and Politou and Papaconstantinou (1995) reported 9 years old specimens from Tunisia and Northern Greece, respectively. Tserpes and Tsimenidis (2001) aged specimens from the Cretan shelf to 5 years from otoliths. We must take account here that different techniques (scales, otoliths) were used in different studies, so some discrepancies could arise. In our estimations, the asymptotic fork length of comber was L_∞ = 33.6 cm and its K value was 0.11, indicating that comber is a fast growing species in Edremit Bay. Papaconstantinou *et al*. (1994) calculated L_∞ = 23.8 cm and its K = 0.3. Tserpes and Tsimenidis (2001) estimated L_∞ = 22.3 cm and its K = 0.39 for comber from Cretan shelf. A trade-off between growth rate (K) and maximum size (L_∞) is often found. This trade off is influenced by several factors, like temperature, mortality, or food availability. Increased food availability causes a shift towards larger maximum size, but may not increase the growth rate. Tserpes and Tsimenidis (2001) discussed the relation between spawning period of comber on Cretan shelf and formation of annuli on otoliths extrapolating that formation of annuli from April to June may be related to the reproductive process.

Pauly (1980) reviewed natural mortality rates for 174 fish stocks, and modal mortality was 0.2 - 0.3 (Vetter, 1988). Obtained values of the natural mortality of comber in the area of study indicate a relatively low natural mortality M = 0.32. The same species may have different natural mortality rates in different areas depending on the density of predators and competitors, whose abundance is influenced by fishing activities (Sparre *et al*., 1989). Direct measurements of M are often impossible to obtain, so identification of quantities which can be assumed to be proportional to M and which are easier to measure (or estimate) has been attempted. An estimate of M by Pauly's formula belongs to the category of qualified guesses. We must also take into account that quality of the input data to the regression analysis from which Pauly's formula was derived can be questioned, since Pauly needed real observations of M which are difficult to obtain. So, any M value which was used for estimation can be questioned. For some species, the values of M seem to be twice or half of what it should be (Sparre and Venema, 1992). Even small changes in the growth parameters used could seriously affect the computed mortality rates (Tserpes and Tsimenidis, 2001). It is rather difficult, proba-

bly unwise, to describe the current position of the stock due to the lack of information on the effect of fishing on recruitment and behaviour pattern of comber. However, the exploitation ratio E = 0.35, revealed light to moderate exploitation of stocks in the studied area. The fisheries strategy should be planned so that the fishing period follows the reproductive period. Most of the estimates of E, for comber from the Cretan shelf (Tserpes and Tsimenidis, 2001) were around 0.7 suggested that a fish stock is optimally exploited at a level of F which generates E = 0.5, Fop = M.

The comber is a synchronous hermaphrodite (Garcia-Diaz *et al*., 1997) and the spawning period is from March to July (Hureau, 1986; Politou *et al*., 1995), while in our study we determined that reproduction occurred between March and May, peaking in April. Garcia-Diaz *et al*. (1997) reported the spawning season of comber from Canary Island (on the basis of both methods: macroscopic and histological) is from February to July, with a peak in May. Same authors noted that agreement between macroscopic and histological staging of gonads was low, but both methods provided similar results in spawning-season determination and size at maturity. They reported almost the same fish size at first maturity L_{50} = 15.2 cm standard length, as like as in our study L_{50} = 15.0 cm fork length. Sabates (1990) pointed that comber spawns in spring and early summer in northwest Mediterranean areas. Bauchot (1987) reported that comber is sexually mature when it reached 3 years. JICA (1993) noted that spawning period is mostly in spring. In the present study the female: male sex ratio was a 1.26:1.

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