http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 5 (10): 1126-1130, 2002

Age, Growth, Sex-ratio, Spawning Season and Mortality of Annular Bream, *Diplodus annularis* Linnaeus (1758) (Pisces:Sparidae) in Edremit Gulf (Aegean Sea)

Hatice Torcu Koc, [1]Dilekturker Cakir and Zeliha Aka
University of Balikesir, Faculty of Science and Arts, Department of Biology, Balikesir, Turkey
[1]Ege University, Faculty of Fisheries, 35100, Bornova-Izmir, Turkey

Abstract: The study was conducted with specimens (N=652) collected from Northern Aegean coasts of Turkey. Females made up 49.38 % and males 50.62 % of the species. The fork length of females varied between 7.3 and 13.8 cm, and of males, varied between 7.5 and 14.0 cm. The von Bertalanffy growth equation was fitted on the basis of mean length-at-age data resulting in parameter values of parameters of $L\infty$ = 18.36 cm, K= 0.14 1/y, t_0=−2.93 for males, $L\infty$ =17.21 cm, K= 0.21 1/y, t_0=−1.73 for females and $L\infty$ =16.62 cm, K=0.20 1/y, t_0=−1.96 for combined sexes. *D. annularis* was grown allometrically for both sexes together with *b*= 2.75 (SE= 3.1854) and relatively rapidly, achieved 26.77 % of the growth during the first year. The comber was a relatively long-lived species. The oldest male and female were estimated to be 7 and 6 years old, respectively. The overall sex ratio males:females was 1:1 The total (Z) and natural (M) mortality rates were 1.15 and 0.37 per year, respectively. The exploitation rate indicates that the population is overexploited (E=0.68). Mean condition factor of annular bream was calculated as 1.281. The seasonal values of gonadosomatic index (I_G) of females indicated that spawning occurred mainly in spring and summer.

Key words: *Diplodus annularis*, Edremit Gulf, age, growth, gonadosomatic index, mortality

Introduction

The annular bream (*Diplodus annularis* L.) is a demersal species which lives in north Atlantic and Mediterranean sea. The habitat of *D. annularis* is restricted to Posidonia beds (Aksiray, 1987; Bauchot and Hureau, 1986; Fischer *et al.*, 1986-87). In the previous studies, this species is widespread in Mediterranean sea and Aegean sea (Bauchot and Hureau, 1986; Mater, 1976), in the Marmara sea (Unsal, 1984). Sexual maturation, reproduction and fecundity of *D. annularis* L. from Tunisia were investigated (Saied and Kartas, 1995). Age and growth patterns of *D. annularis, D. sargus, D. vulgaris* in adult populations were investigated in the north-western Mediterranean sea (Gordoa and Moli, 1997). Weight-length relationship for *D. annularis* was investigated in the south-western coast of Portugal (Erzini, 1997).

Maturation and gill net selectivity of two small sea breams (genus *Diplodus*) from the coast of south Portugal were studied (Santos *et al.*, 1998). Bio-ecological aspects of sea breams genus (*Diplodus*) from the gulf of the Lion were studied (Girardin, 1978).

The existence of this species was pointed out in Turkish seas (Erazi, 1942). Bio-ecology of *D. annularis* L. was studied briefly from Black sea (Slastenenko, 1956). Age, growth, maturation, and local migration of *D. annularis* L. were studied from Izmir Gulf (Mater, 1968). The biology of *D. annularis* L. was studied from the sea of Marmara (Unsal, 1984). The biology and ecology of the species were also reported by Anonymous (1993). Although different aspects of its biology have been studied, such as settlement (Garcia-Rubies and Macpherson, 1995; Harmelin-Vivien *et al.*, 1995), age and growth of *D. annularis* L. from Catalan coast (Gordoa and Moli, 1997), any current information is not available on mortality.

The objective of present study is to point out the data on the age and size distribution, length-weight relationship, sex composition, gonadosomatic index, condition factor, and mortality of annular bream (*D. annularis* L.) from Edremit Gulf (Aegean Sea).

Materials and Methods

Collection: A total of 652 specimens of annular bream, *D. annularis* was collected with trawl hauls at monthly intervals, between September 1997 and September 1998. Location was between Altinoluk and Bozburun (Fig. 1). The trawling was done only in the daytime at depths ranging from 45 to 60 m. Duration of hauls was 2 hours and the speed was 2 miles per hour. The trawl was equipped with a 22 mm mesh size net (knot to knot) at the cod-end.

For each individual, the following variables were recorded: body length (F_L to the lowest 0.5 cm), total weight (TW), gonad weight (GW) and somatic weight (SW). These were recorded with a 0.01 g accuracy. Sex and maturity stages were also determined. The five-point maturity scale used was a simplified version of Pinto and Andreu (1957) maturity scale (stage I=virgin or resting, stage II=maturing, stage III=pre-maturing, stage IV=spawning, and stage V=post-spawning).

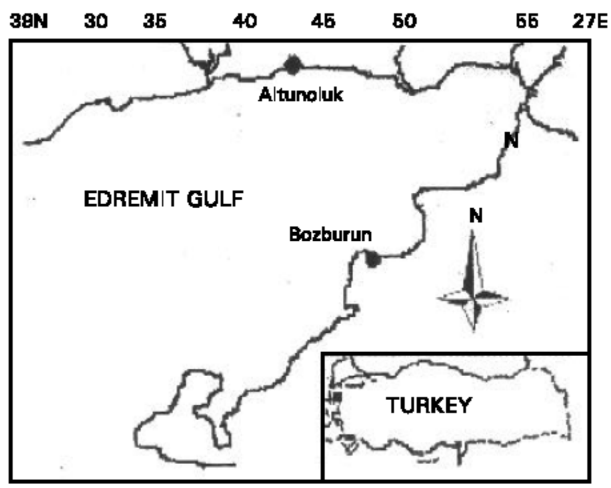

Fig. 1: The sampling area in Edremit Gulf, Aegean sea

Growth: Sagittal otoliths were removed. They were stored dry in paper envelopes and later used for age determination by the method of Chugunova (1963). Age was read from whole otoliths immersed in glycerine (25 %) and alcohol (75 %) and viewed with a low-power binocular microscope under reflected light aganist a black background.

The length and weight relationship was determined according to the equation given below (Sparre and Venema, 1989-1992).

$$W = a\,L^b,$$

where W is the total body weight (g), L the fork length (cm), and a and b are constants.

Growth was expressed by the equation of von Bertalanffy (1957):

$$L_t = L_\infty [1-e^{-K(t-t_0)},],$$

where L_t is the fork length at age t, L_∞ the asymptotic fork length, K the growth curvature parameter and t_0 is the theoretical age when fish would have been at zero fork length. These parameters were estimated according to von Bertalanffy growth equation (Sparre and Venema, 1989-1992).

Sex ratio and reproduction: Seasonal sex ratio, expressed as female:male, was analyzed. Deviations from 1:1 null hypothesis were statistically tested by χ^2–test. Spawning period was determined from the analysis of the seasonal evolution of the percentages of mature individuals and the mean gonadosomatic index (I_G) throughout the one-year period. In these analyses, only those specimens with a size larger than the length at first maturity were considered, thus avoiding possible size-dependent biases because of the uneven length distribution in seasonal samples. Individual I_G was calculated from the expression:

$$I_G = (GW/SW) \times 100.$$

Length at first maturity (L_{50}) was estimated in both sexes and for the species from the percentages of mature individuals (stage III, IV and V) occurring over the reproductive period (previously determined from seasonal mean I_Gs. The total length at which 50% of the individuals were fully mature was estimated from fitting the log-transformed relative frequencies of mature individuals by length class by the least squares method to a logistic curve (Sparre *et al.*, 1989).

Condition factor: Annular bream condition status has been determined seasonally from the condition factor (CF) using the following two expressions: the Fulton's (1911 in Millan, 1999) condition factor ($CF=SW/TL^3$) TL is measured in cm. The somatic weight (SW) [SW= TW (Length weight)-GW (somatic weight)] was used in order to avoid the influence of gonad development on the true somatic conditions of individuals (Millan, 1999).

Mortality: Total mortality rate was estimated for both sexes using the cumulated catch curves (Jones and Van Zalinge, 1981)

$$\log_e (N_c) = a + Z/k \log_e (L_\infty - L)$$

N_c is the cumulative number of the fish of length L and above, L_∞ and k are the parameters of the von Bertalanffy equation, Z/k the slope of the curve. For the estimation of the total mortality (Z) catch curves were developed from the length distribution. Natural mortality (M) was estimated using the empirical formula of Pauly (1980, 1983):

$$\log(M) = -0.0066 - 0.2791\log(L_\infty) + 0.65431\log(k) + 0.46341\log(T),$$

where L_∞ and k are the parameters derived from von Bertalanffy equation and T the mean annual environmental temperature at the surface of the study area in degrees centigrade (16°C for 0-30 m depth). Following estimation of Z and M, the fishing mortality rate (F) was estimated from:

$$F=Z-M,$$

and the exploitation ratio (E) from:

$$E=F/Z$$

Results and Discussion

The length-frequency distribution: Of the 652 specimens measured, the fork length of females (49.38%) ranged from 7.3 to 13.8 cm. The range (7.5-14.0 cm) for males (50.62 %) was higher than females (Fig. 2). The immature individuals were regarded as males because of rudimentary ambisexuality in the species (Unsal, 1984; Said and Kartas, 1995).
However, the difference between overall mean fork length of female and male fish was non significant.

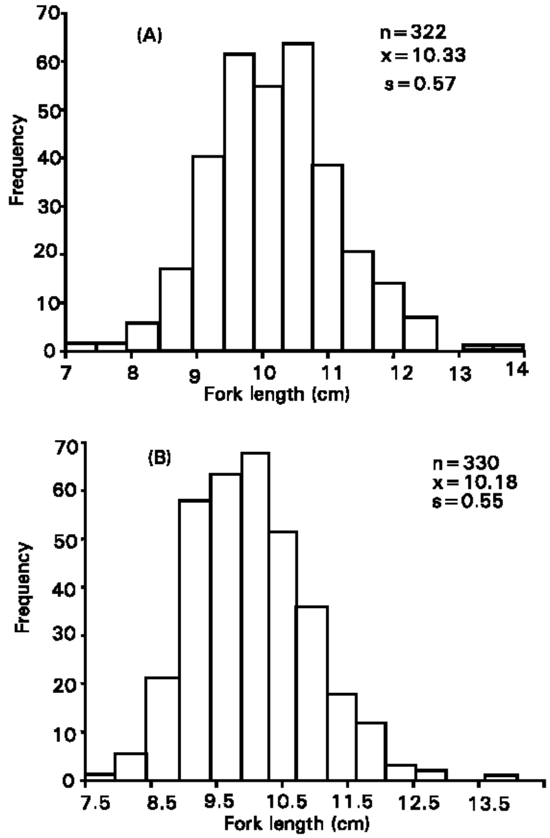

Fig. 2: Length-frequency distribution of annular bream: (A) females, (B) males ((x) mean and (s) standard deviation

The fork length-weight relationship: The fork length-weight relationships were evaluated separately for males, females (Fig. 3). The calculated weight/length equation for females was: $W=0.0367L^{2.7976}$ (r =0.93); for males was $W=0.0455L^{2.6964}$ (r =0.92). Weight increased negative allometrically with size since the value of b =2.7976, b =2.6964, respectively had a significant difference from the value 3.0 ($P<0.05$).

Age and growth: The results of otolith rings are given in Table 1 and Table 2. The maximum age determined was 7. The age 3 (49.38%) were dominant for females and 2 (44.54%) for males. In females, the age 2 (36.96%), 4 (9.32%), and 5 (3.14%), followed

Table 1: The calculated and observed fork length at different age groups

Age	Caught in nature		Calculated	
(years)	Female	Male	Female	Male
1	7.30±0.3872	8.00±0.3153	7.44	14.11
2	9.35±0.2713	9.35±0.2555	9.27	9.35
3	10.62±0.5524	10.53±0.5172	10.76	10.57
4	11.81±0.4439	11.73±0.4301	11.97	11.62
5	12.35±1.2727	12.56±0.0001	12.95	12.52
6	13.80±0.0001	13.40±0.0001	13.75	13.31
7	-	14.00±0.00	-	13.99

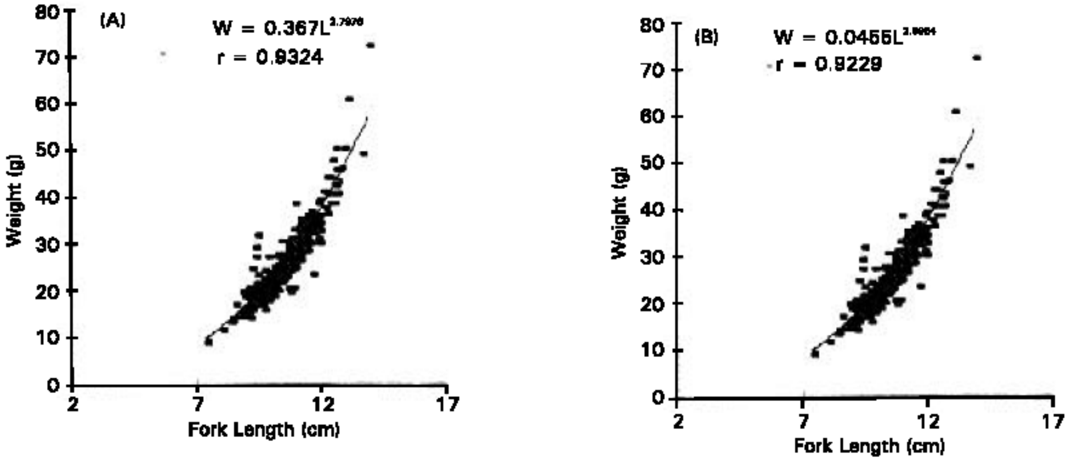

Fig. 3: Length–weight relationships: (A) females and (B) males

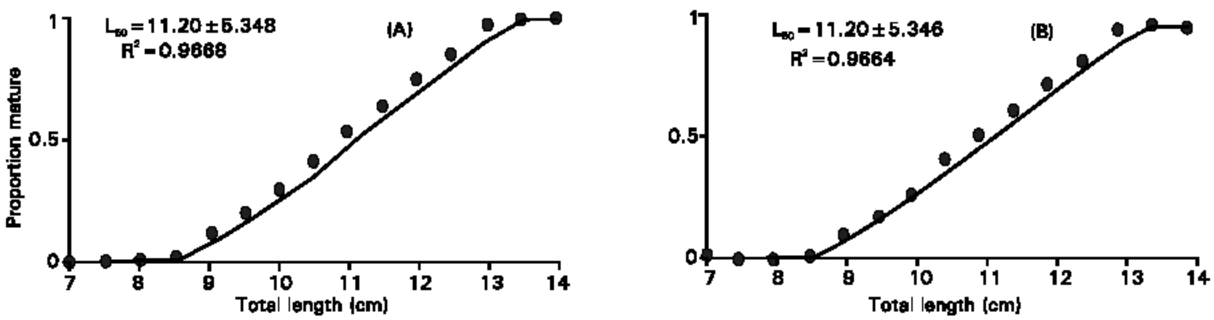

Fig. 4: Maturity ogive and length at first maturity (L_{50}) in (A) females and (B) males of *D. annularis* for the whole study period.

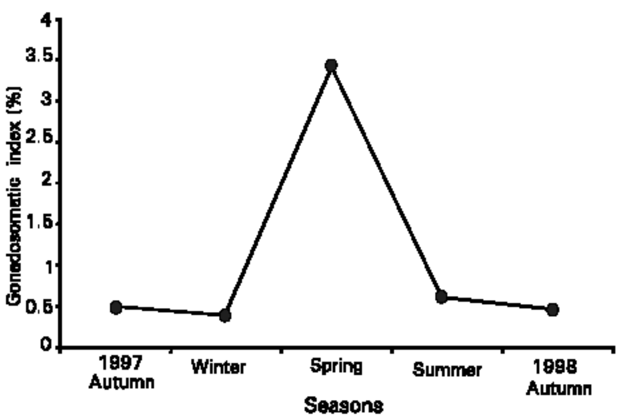

Fig. 5: Seasonal cycle of gonadosomatic index of *D.annularis*.

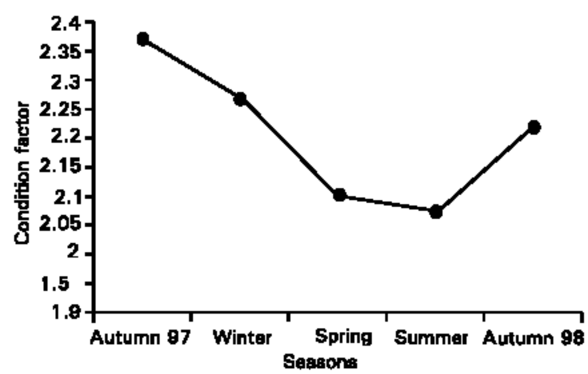

Fig. 6: Seasonal cycle of the Fulton's condition factor of *D. annularis*.

it respectively. In males, age 3 (42.42%) was followed by 4 (10.30%), and 1 (1.82), respectively. The greater portions of the population are composed by the ages, 3 and 2.

The estimated parameter values of the von Bertalanffy growth equation were:

L_∞ = 18.36 cm, K = 0.14 1/y, t_0 = -2.936 (y), r^2 = 0.923 for males,
L_∞ = 17.21 cm, K = 0.21 1/y, t_0 = - 1.73 (y), r^2 = 0.932 for females
L_∞ = 16.62 cm, K = 0.20 1/y, t_0 = -1.96 (y), r^2 = 0.928 for both sexes combined.

The value of L_∞ is higher than the maximum observed length. A theoretically maximum length of 16.62 cm is realistic because the largest specimen sampled during the surveys was 14.0 cm.

Sex ratio and reproduction: It was found that of the 652 specimens measured, 322 were females (49.38%) and 330 (50.62%) were males, but the gonads of 291 males included in various age groups had only testicular tissue while the gonads of 39 males (5.98% in all specimens) belonging to IV and VII age groups had partly developed ovaries together with testes. On the basis of Reinboth's (1970) study, these individuals were considered as males.

The overall female:male ratio (0.97) was similar with expected 1:1 ratio (X^2 = 18.82, p > 0.001). The female:male ratio and corresponding chi-square (X^2) values for per season are presented in Table 3.

Table 2: Age-length key for annular bream in Edremit Bay based on scale reading

Length group (cm)	Age (years) 1	2	3	4	5	6	7	Total N
7	3.00							3.0
8	13.00	35.00						48.0
9		130.00	100.00					230.0
10			225.00					225.0
11			73.00	30.00				103.0
12			1.00	33.00	1.0			35.0
13				3.00	1.0			4.0
14					1.0	2.00	1.0	4.0
Total (N)	16.0	165.00	399.00	66.00	3.0	2.00	1.0	652.0
%	2.5	25.00	61.00	10.00	0.5	0.31	0.2	100.0
Mean L (cm) $\pm$SD	7.08	9.11	10.33	12.12	13.27	14.2	14.3	
	0.36	0.25	0.705	0.434	1.01	0.14	-	
Mean W (g) $\pm$SD	13.37	18.45	25.87	39.92	44.22	56.88	72.13	
	2.15	2.73	4.77	6.76	3.00	5.32	-	

Table 3: Numbers of female and male annular bream per sampling season and results of the chi-square (X^2)

Seasons/Year	Autumn/97	Winter/97	Spring/98	Summer/98	Autumn/98
No. of females	93.0	75.0	6.0	133.0	15.0
No. of males	73.0	73.0	19.0	128.0	37.0
Female:male ratio	1.3	1.0	0.3	1.0	0.4
Female:male significance	No	No	No	No	No
Different from 1:1 (P)	<0.001	<0.001	<0.001	<0.001	<0.001
Chi-square (x^2)	2.91	0.1	5.77	0.24	9.30

Table 4: Age structure, parameters of the length-weight relationship (*a, b*) and the growth (L_∞ k, to) of the *D. annularis*

Authors	Study area	Max.age (years)	N	a	B	r_2	L_∞	k	T_o	Length
Mater (1976)	Gulf of Izmir	9								9-11
Girardin (1978)[b]	Gulf of Lion	5		-	3.34	-	17.12	0.56	-0.0226	
Unsal (1984)	Marmara Sea	8	-	-	-	0.84	19.65	-	-	5-18
Gordoa and Moli (1997)[a]	Catalan (Spain)	6-7	57	0.0252	2.79	0.81	20.37	0.544	-0.033	9-20
Saied and Kartas (1995)[a]	Sud-est Tunusia	-	-	-	-	-	-	-	-	5-19
This study (2000)[b]	Gulf of Edremit	7	652	3.075	2.75	0.85	16.620	0.20	-1.96	7.3-14

[a]Using total length [b]Using fork length

Length at first maturity: For the whole period, length at first maturity (L_{50}) was estimated as 11.20 ± 5.348 cm for females and 11.13 ± 5.346 cm for males (Fig. 4).

Examination of the sampled female ovaries showed that the sexual maturation started after age group II. The I_G results revealed that the reproduction occurred from spring to the end of the summer when the I_G reached its highest level (Fig. 5).

Condition factor: From 1997 to 1998, seasonal trends in CF showed a rather apparent seasonal cycle (Fig. 6), annular bream reaching a higher condition from autumn to winter and a lower condition from spring to summer. This cycle of CF showed a negative correlation with that of I_G ($r=0.867$; $n=262$; $p<0.01$) (Fig. 6).

Mortality: The fishing net used was capable of catching *D. annularis* with a fork length 7.3 cm or greater. Total mortality was estimated from both sexes combined. The total mortality corresponding with slope of the curve was found to be $Z=1.15$/year. The natural mortality (M) was found to be $M=0.37$/year. Then the calculation of the fishing mortality gave $F=0.78$/year. The exploitation rate was computed as $E=0.68$, indicating that the fishing pressure exerted on the *D. annularis* in Edremit Gulf, is rather high.

The sagittal otoliths of *D. annularis* show distinct opaque and hiyaline bands which can be used for age determination. Few otoliths were rejected.

D. annularis has relatively long lifespan. There are seven age classes of *D. annularis* in Edremit Gulf, compared with eight age classes in Marmara Sea (Unsal, 1984). The seven age classes life cycle exhibited by *D. annularis* in Edremit gulf concurs with the expectations of Gordoa and Moli (1997), who proposed six and seven classes structure, while there is a five age classes structure in Lion Gulf (Girardin, 1978). Mater (1976) found that there are nine age classes in some populations of *D. annularis* in Izmir Gulf (Table 3).

The rapid early growth rate after age one decreased to age seven gradually. The estimated L_∞ (16.62 cm) derived from the von Bertalanffy equation was not in agreement with the results of previous investigators, except for the result of Girardin (1978). The overall growth rate indicated by the von Bertalanffy growth coefficient ($k=0.20$/year) calculated in the present study has been the lowest found in the literature so far. A trade-off between growth rate k and maximum size L_∞ is found because of several factors such as temperature, mortality or food availability and this may also be due to the ageing procedure (otoliths) (Table 4).

There is not a protandry but a rudimentary ambisexuality in *D. annularis* (Unsal, 1984). Saied and Kartas (1995) also mentioned rudimentary and protandrous hermaphroditism. The gonado-somatic index and the degree of maturity of gonads revealed that the spawning period of this species last from winter to summer. According to other investigators who studied in this subject (Unsal, 1984; Mater, 1968-1976; Bauchot, 1986), the spawning period of *D. annularis* (L.) in the Mediterranean Basin, Marmara Sea, and Kerkenneh Islands (Sud-Est Tunisien) also falls in spring and summer but there are differences as to years, regions and the investigators in the same region.

The proportion of males and females of *D. annularis* in the population appears to depend on temporal factors such as the reproduction period. The almost equal numbers of the both sexes are born and enter into the population, while an unequal sex ratio during the reproduction period indicates that during the spawning season more males appeared than females (Table 3).

The lack of 0+ age group observed is due to the selectivity of the cod-end used in trawl nets. The low percentage of age groups VI-VII and the presence of individuals up to 14 cm can be contributed to the outcome of extremely intensive fishing efforts, which is not under control. *D. annularis* has commercial value due to its abundance and its relative easiness of catch.

The length-converted catch curves showed a typical form and justified the estimation of a single value of Z in all fish (Pauly, 1980, 1983). In every case, the exploitation ratio (E) is higher than 0.50. As a rule, a fish stock is optimally exploited at level of fishing mortality which generates $E=0.50$, where $F_{opt}=M$, but in present study $F>F_{opt}=M$ (Gulland, 1971 in Pajuelo and Lorenzo, 1998). Therefore, the stock of annular bream is being heavily exploited.

The fisheries strategy should be planned so that the fishing period follows the reproductive period.

References

Aksiray, F., 1987. The Identification Key of Turkish Marine Fishes (4th ed.), Istanbul University Press, Istanbul, 349, pp: 87.

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

Chugunova, N.I., 1963. Age and Growth Studies in Fish. National Science Foundation, Washington, DC:132.

Erazi, R. A., 1942. Fishes of Bosphorus and Marmara Sea., J. Ist. Üniv. Sci. Fac. Serial, B 7: 103-115.

Erzini, K., 1997. Weight-length relationships for selected five fish species of the small-scale demersal fisheries of the south-west coast of Portugal. Fish. Res. 30: 253-256.

Fischer, W., M. Schneider and M.L. Bauchot, 1986-87. Fiches FAO d'identification des especes pour les pour les besoins de la peche. (Rev. 1). Mediterranee et Mer Noire, Zone de Peche 37, Rev.1, Vol II, Vertebres. FAO, Rome, 1317-1319.

Garcia-Rubies, A. and E. Macpherson, 1995. Substrate use and temporal pattern of recruitment in juvenile fishes of the Mediterranean littoral. Marine Biologia, 124:35-42.

Girardin, M., 1978. Les Sparidae du Gulf du Lion. Ecologie et biogeographie. Deaustl, Montpellier, pp: 140.

Gordoa, A. and B. Moli, 1997. Age and growth of the sparids *Diplodus vulgaris*, *D. sargus* and *D. annularis* in adult populations and the differences in their juvenile growth patterns in the north-west Mediterranean Sea. Fish Res., 33: 123-129.

Harmelin-Vivien, M.L., J.G. Harmelin and F. Leboulleux, 1995. Microhabitat requirements for settlement of juvenile sparid fishes on Mediterranean rocky shores. Hydrobiology, 300/301: 309-320.

Hureau, J.C. and M.L. Bauchot, 1986. Sparidae. In: Fishes of the North-eastern Atlantic and the Mediterranean. Whitehead *et al.* (Eds.), Vol., 2: 883.

Anonymous, 1993. Final report of Demersal Fisheries Resource Survey in the Republic of Turkey. Submitted by Sanyo-Techno-Marine Inc. and Sponsored by Japan International Cooperation Agency, 254.

Jones, R. and N.P. Van Zalinge, 1981. Estimates of mortality rate and population size for shrimp in Kuwait Bull. Marine Sci., 2: 273-288.

Mater, S., 1968. Investigations on the population of annular bream, *Diplodus annularis* L. in Izmir Gulf, Ege Univ. Sci. Fac. Rep., 50.

Mater, S., 1976. Biological and ecological investigations on the populations of Sparidae in Izmir Gulf and its vicinity. Ege Univ. Sci. Fac. Fak. Rep., 201-1974: 5-53.

Millan, M., 1992. Descripcion de la pesqueria de cerco en la region Suratlantica Espanola y Atlantico-Norte Marroqui. Inf. Tec. Inst. Esp. Oceanogr., 136-170.

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

Pauly, D., 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. J. du Cons. Explor. Mer., 39: 175-192.

Pauly, D., 1983. Some simple methods for the assesment of tropical fish stocks. FAO Fish. Technol. Pap. 234: 1-52.

Pinto, J. and B. Andreu, 1957. Echelle pour la caracterisation des pevolution de l'ovaire de sardine, *Sardina pilchardus* (Walb.), en raport avec l'histophysiologie de la ganade. Proc.Tech. Pap. Gen. Fish. Coun. Medit., 4: 393-411.

Reinboth, R., 1970. Intersexuality in fishes. Mem. Soc. Endocrinol. 18: 515-543.

Ricker, W.E., 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Bd. Canada, 191: 382.

Saied, A. and F. Kartas, 1995. Sexuaille et reproduction du Sparallion *Diplodus annularis* des iles Kerkennah (Sud-Est Tunisien). Rapp. Comm. Int. Mer Medit., 31: 2.

Santos, R., 1998. Maturation and gill-net selectivity of two small sea breams (genus *Diplodus*) from the Algarve coast (south Portugal). Fish. Res., 36: 185-194.

Slastenenko, 1956. Fishes of Karadeniz Basin: 362-368, Istanbul.

Sparre, P., E. Ursin and S.C. Venema, 1989. Introduction to Tropical Fish Stock Assesment Part 1: Manual. FAO Fish. Tech. L. Pap. Rev., 306: 377.

Sparre, P. and C.S. Venama, 1992. Introduction to Tropical Fish Stock Assesment Part 1: Manual. FAO Fish. Tech. L. Pap. Rev., 306: 376.

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

Von, L. B., 1957. Quantitative laws in metabolism and growth. Q. Rev. Biol., 32: 217-231.