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Growth Characteristics, Sex Inversion and Mortality Rates of Striped Sea Bream, *Lithognathus mormyrus* L., in İskenderun Bay

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Abstract: The total length of examined samples of striped sea bream in İskenderun Bay ranged from 9.1 to 27.7 cm. The length-weight relationship constants for males (a = 0.0112, b = 3.042) and females (a = 0.0105, b = 3.069), showed no significant difference from isometric growth ($P < 0.05$). Von Bertalanffy growth parameters in length were L_∞ = 26.55 cm, K = 0.203 y^{-1} and t_o = -1.81 y for males and L_∞ = 32.64 cm, K = 0.136 y^{-1} and t_o = –2.12 y for females. Sex inversion occurred at lengths between 11.2 and 22.9 cm in age groups I-VI. Males were observed up to a length of 22.8 cm. Total, natural and fishing mortality rates were Z = 1.15 y^{-1}, M = 0.48 y^{-1} and F = 0.67 y^{-1} respectively. The exploitation rate of E = 0.60 indicates that the population is being heavily exploited. Reproductive activity of striped sea bream in İskenderun Bay took place between the second half of April and early August, with the greatest intensity in May. Lengths at first maturity were 13.4 cm for males and 13.9 cm for females.

Key Words: Striped sea bream, İskenderun Bay, Growth and reproductive characteristics, Mortality, Exploitation rates, Sex inversion (hermaphroditism)

İskenderun Körfezi'ndeki Çizgili Mercan Balığının, *Lithognathus mormyrus* L., Büyüme Özellikleri, Cinsiyet Dönüşümü ve Ölüm Oranları

Özet: İskenderun Körfezi'ndeki çizgili mercan balığının incelenen örneklerinde toplam boy 9,1-27,7 cm arasında değişmiştir. Boy-ağırlık ilişkileri erkek (a = 0,0112, b = 3,042) ve dişilerde (a = 0,0105, b = 3,069) izometrik büyümeden önemli bir farklılık göstermemiştir ($P > 0,05$). Boyca von Bertalanffy büyüme parametreleri erkekler ve dişiler için sırasıyla, L_∞ = 26,55 cm, K = 0,203 $yıl^{-1}$, t_o = -1,81 yıl ve L_∞ = 32,64 cm, K = 0,136 $yıl^{-1}$, t_o = –2,12 yıl olarak hesaplanmıştır. Eşey oranının (E:D) 1,09/1,00 olarak saptandığı bu çalışmada, eşey dönüşümünün I ve VI. yaşlar arasında (11,2-22,9 cm boy aralığında) gerçekleştiği ve maksimum 22.8 cm'e kadar erkek bireylerin olduğu tespit edilmiştir. Toplam (Z), doğal (M) ve balıkçılık nedeniyle olan (F) ölümlerin sırasıyla, Z = 1,15 $yıl^{-1}$, M = 0,48 $yıl^{-1}$ ve F = 0,67 $yıl^{-1}$ olarak hesaplandığı; ve E = 0,60 olarak bulunan sömürülme oranı ile populasyonun yoğun bir şekilde avcılık baskısı altında olduğu belirlenmiştir. Nisanın ikinci yarısından Ağustos başına kadar uzun bir süreyi kapsayan üreme faaliyeti, yoğun olarak Mayıs ayında gerçekleşmiştir. İlk eşeysel olgunluk boyları erkekler ve dişiler için sırasıyla 13,4 ve 13,9 cm olarak hesaplanmıştır.

Anahtar Sözcükler: Çizgili Mercan, İskenderun Körfezi, Büyüme ve Üreme Özellikleri, Ölüm, Sömürülme Oranları, Eşey Dönüşümü (Hermafroditlik).

Introduction

The striped sea bream, *Lithognathus mormyrus* L., is widely distributed in the Mediterranean and Red seas (though not the Black Sea), and the Atlantic and West Indian oceans, inhabiting littoral waters on sandy or sandy-muddy bottoms down to a maximum depth of 50 m, but predominantly between 10 and 30 m (Bauchot et al., 1986).

Adequate data on the age, growth, mortality and reproduction properties of this species from İskenderun Bay have not been published. Suau (1970) studied the biology and life history of striped sea bream from the Spanish Mediterranean. Kraljevic et al. (1995, 1996) studied the age, growth, mortality and sexual maturity of this species from the eastern coast of the Adriatic Sea and the Northern Adriatic. Erzini et al. (1995) studied its growth and reproduction from the south coast of Portugal.

This paper deals with some aspects of the age, growth, mortality, spawning and sex inversion of striped

sea bream collected from İskenderun Bay (Northeastern Mediterranean).

Materials and Methods

The study was performed in İskenderun Bay, Northeastern Mediterranean (Figure 1). A total of 3336 specimens of striped sea bream were collected by experimental trawl nets at depths of 0-30 m from October 1998 to September 1999. For each fish, total length (L) was measured to the nearest centimeter and total weight (W) to the nearest 0.01 g. Sex and maturity were determined macroscopically. The weight of the gonads (W_g) was recorded to the nearest 0.01 g. The sagittal otoliths were chosen for age reading and interpretation since they are the largest and most commonly used in these types of studies (Secor et al., 1991). Otoliths removed from 3336 individuals were cleaned, dipped in hydrochloric acid and sodium hydroxide solution, and then ethyl alcohol (Chugunova, 1963; Chilton and Beamish, 1982). In order to enhance the contrast and thus facilitate the reading and interpretation of growth marks the otoliths were dipped in glycerol and observed under a binocular dissecting microscope with reflected light at a magnification of x16. All otolith readings and interpretations were performed independently by three researchers (Erzini et al., 1995). Designation of age was done according to Chugunova (1963), Williams and Bedford (1973) and Livadas (1988).

Relationship between weight and length was calculated applying the exponential regression equation, $W = aL^b$ (Ricker, 1975). Confidence intervals (CI) were calculated for the slopes (b) to see if these were statistically different from 3 ($\alpha = 0.05$). In addition, the differences between the slopes (b) of males and females were tested with the t-test as given by Düzgüneş et al. (1983).

Von Bertalanffy growth curves were fitted to the observed length at age data of the resulting age-length key by means of a Marquard's algorithm for non-linear least squares parameter estimation (Saila et al., 1988). The form of the growth curve is $L_t = L_\infty [1-e^{-K (t-t_0)}]$ (Beverton and Holt, 1957). Statgraphics version 3.0 was used to estimate the growth and the length-weight parameters.

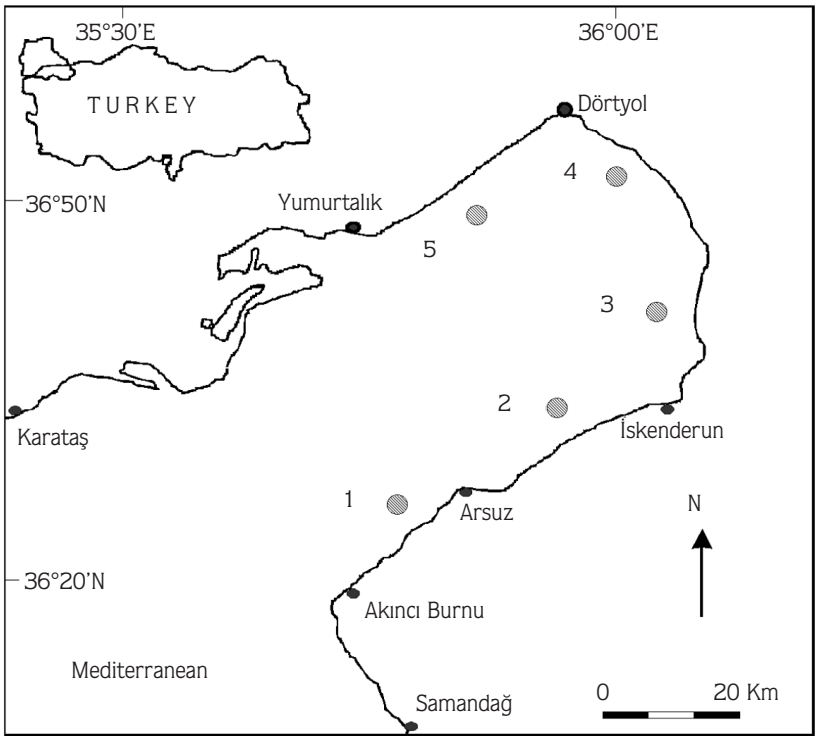

Figure 1. Sampling stations in İskenderun Bay, Northeastern Mediterranean.

Instantaneous total mortality rate (Z) was calculated from the length-converted catch curve (Pauly and Munro, 1984), using the program Fisat (Gayanilo et al., 1994). The natural mortality rate (M) was estimated by using the calculated (L_∞), (K) and the annual mean water temperature (23.1 °C) based on the empirical equation of Pauly (1983). Fishing mortality rate (F) was estimated from F = Z - M, and the exploitation rate (E) from E = F / Z.

The spawning season was identified by using the monthly changes of the gonadosomatic index (GSI), calculated as follows: GSI = 100 W_g / Wt (Anderson and Gutreuter, 1983). For the estimation of mean length at 50% maturity (length at first maturity), a logistic function was fitted to the proportion of the mature individuals by size class using non-linear regression. The function used for calculating length at first maturity was $P = 1/\{1+\exp[-r(L-L_m)]\}$, where (P) is the proportion mature in each size class, (r) (-b slope) is a parameter controlling the slope of the curve and (L_m) is the size at 50% maturity. $L_m = a/r$, where a is intercept (Saila et al., 1988). Differences between the length at first maturity of males and females were tested with a regression approach by comparing the slopes and intercepts of 2 equations belonging to both sexes. Gonads were removed, weighed to an accuracy of ±0.001 g, and identified as ovaries or testes from examinations of the gonadal tissue by neck eye for bigger fish and with a dissecting microscope for smaller fish (King, 1996). The age group VII was ignored in the statistical calculations since the number of samples was insufficient statistically.

Results

Age and growth

The ages of the fish ranged from I to VII years. Fish ranged in size from 9.1 to 27.7 cm, and in weight from 8.9 to 303.2 g. Males ranged from 9.1 to 22.8 cm in length and from 8.9 to 158.17 g in weight. The length of females ranged from 10.4 to 27.7 cm and weight from 12.31 to 303.2 g. Sex reversal started between 11.2 cm and 22.8 cm. Von Bertalanffy growth parameters for males, females and their totals are given in Table 1.

Length-weight relationship

The slopes of the length-weight regressions did not differ significantly between the sexes (t-test; $P < 0.05$). Isometric growth was observed for striped sea bream, and the values of (b) for males, females and their totals were not significantly different from 3 (Table 2).

Sex inversion

Among the examined specimens; 1626 individuals were males, 1612 were females and 98 were hermaphrodites. The overall male to female ratio of 1:0.99 in favor of males, was not significantly different from 1:1. The striped sea bream is a hermaphrodite, and so males predominated in smaller size intervals. Sex inversion took place between 11.2 and 22.8 cm in age groups I-VI. Males were observed up to a length of 22.8 cm. Individuals greater than 22.8 cm long were all females (Figure 2).

Table 1. Von Bertalanffy growth parameters in length for males, females and their totals.

Sex	L_∞ (cm)	K (y^{-1})	t_0 (y)	r^2 (Determination coefficient)
Males	26.55	0.203	-1.81	0.996
Females	32.64	0.136	-2.34	0.989
Total	30.22	0.157	-2.12	0.995

Table 2. Length-weight relationship parameters for each sex and their totals (SE: Standard error, r^2: Determination coefficient, CI: confidence interval, n: Sample size).

Sex	a	b	SE (b)	n	r^2	CI
Males	0.0112	3.042	0.0316	1626	0.982	2.956-3.063
Females	0.0105	3.069	0.0327	1611	0.980	2.964-3.086
Total	0.0113	3.046	0.0198	3335	0.982	2.979-3.068

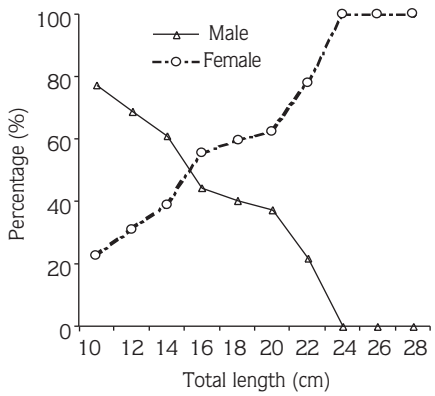

Figure 2. Percentage sex inversion of *L. mormyrus* in each length group (Length groups: 10: 9-11, 12: 11-13, 14: 13-15,..... 22: 21-23, 24: 23-25 cm).

Length at first maturity

Differences between the lengths at first maturity for males and females were not statistically significant ($P > 0.05$). The maturity ogives for the striped sea bream show that 50% of males and females are sexually mature at total lengths of 13.4 and 13.9 cm respectively (Figure 3).

(Males) $P_{male} = 1/\{1+\exp[-1.047(L-13.4)]\}$

$r = 0.995$ $n = 13$

(Females) $P_{female} = 1/\{1+\exp[-1.026(L-13.9)]\}$

$r = 0.992$ $n = 14$

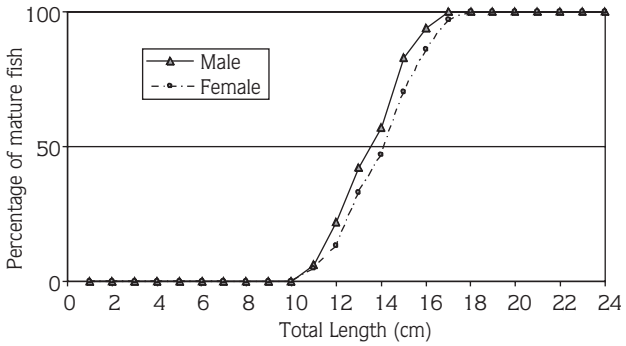

Figure 3. Ogive of 1st maturity for the *L. mormyrus* in İskenderun Bay.

Spawning season

The GSI values of females were usually higher than those of males, and both indices followed the same pattern (Figure 4). Spawning continued from the second half of April to early August, with the greatest intensity occurring in May.

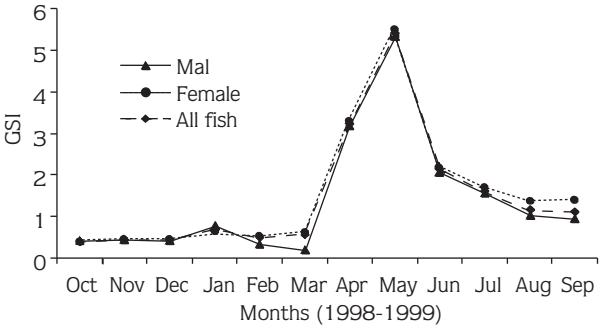

Figure 4. Monthly change in the GSI of *L. mormyrus*.

Mortality

Total mortality, corresponding to the slope of the descending limb of the catch curve, was 1.15 y^{-1} (Figure 5). Inserting in the equation, the growth parameters (K, L_∞) and the mean annual sea surface temperature at the study area (T = 23.1 °C), M was 0.48 y^{-1}, with fishing mortality F = 0.67 y^{-1}. With the values of M and F available, the exploitation ratio was computed as E = 0.60.

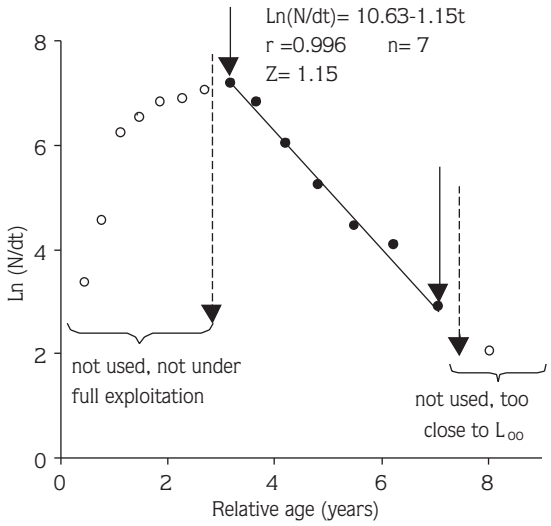

Figure 5. Length-converted catch curve of *L. mormyrus*. (Arrows indicate points used for the regression for the natural logarithm of (N) on age, (n) is number of fish per length class L_1-L_2 corresponding to age class t_1-t_2, dt = t_2-t_1 and t = $(t_1+t_2)/2$).

Discussion

The striped seabream from İskenderun Bay is a protandrous hermaphrodite, as has been reported by

many researchers (Suau, 1970; Arias, 1980; Besseau, 1990; Besseau et al., 1991; Besseau and Bruslé-Sicard, 1995; Kraljević et al., 1995, 1996). Correspondingly, males were dominant in the lower length classes of 9-17 cm. Sex inversion was indicated mainly at lengths between 11.2 and 22.8 cm, in age groups I to VI. The maximum length observed for males in this study was 22.8 cm. Suau (1970) established the presence of males and females in almost all length groups (10-24 cm).

Kraljević et al. (1995) presented individual age categories of striped sea bream from Mirma Bay in the northern Adriatic as follows: age 2.5: 19.4 cm; age 3.5: 24.1 cm; age 4.5: 26.5 cm; age 5.5: 29.4 cm; age 6.5: 31.1 cm; and age 7.5: 32.8 cm (5 months after mid-spawning time), and from Kaštela Bay in the middle Adriatic the results were age III: 21.7 cm; age IV: 26.8 cm; age V: 28.4 cm; age VI: 30.3 cm; and age VII: 31.6 cm. Kraljević et al. (1996) also presented individual age categories of striped sea bream from the northern Adriatic as follows: age III: 20.8 cm; age IV: 25.7 cm; age V: 28.1 cm; age VI: 30 cm; and age VII: 31.3 cm. These values differ considerably from the present results (age I: 11.80; age II: 14.54 cm; age III: 16.71 cm; age IV: 18.55 cm; age V: 20.57 cm; age VI: 21.86 cm; and age VII: 27.7 cm). However, the results obtained in our study are similar to those reported by Suau (1970) for the eastern coast of Spain (age II^+: 14.5 cm; age III^+: 17.8 cm: age VI^+: 20.9 cm).

Asymptotic length of L_∞ = 30.22 cm in İskenderun Bay is smaller than that reported by Suau (1970), L_∞ = 33.3 cm; Kraljević et al. (1995), L_∞ = 37.3 cm for Mirna Bay in the northern Adriatic and L_∞ = 36.2 cm for Kaštela Bay; and Kraljević et al. (1996), 40.1 cm from the northern Adriatic. The growth rate of this species in İskenderun Bay is slower than in other investigated regions.

Differences in growth parameters between regions can be attributed to the difference in the size of the largest individual sampled in each area. It is possible that the variations in the population parameters of striped sea bream represent epigenetic responses to the different conditions, such as temperature and food, prevailing in different regions. It has been observed that cool waters produce larger, older and later maturing individuals of a species than do warm waters (Ross, 1988). The mean annual temperature in İskenderun Bay is 23.1 °C, while in the northern Adriatic it is 14.5 °C and in the middle Adriatic it is 16.3 °C (Zore-Armanda, 1991). Thus the differences in growth parameters may be connected to temperature, and growth in İskenderun Bay is slower than in the other areas.

The relationship between length and weight for this species shows that growth in weight is isometric (b = 3.046) with a 95% confidence interval of $2.979 \leq CI \leq 3.068$. Kraljević et al. (1995) reported isometric growth (b = 3.05) for Mirna Bay in the northern Adriatic and in Kaštela Bay in the middle Adriatic negative allometric growth (b = 2.69). Kraljević et al. (1996) reported isometric growth (male = 3.02, female = 3.06) in the northern Adriatic. Suau (1970) reported positive allometric growth (b = 3.43) in eastern Spain. This variation in the constants could be attributed to different slopes in ontogenetic development, as well as to differences in age, maturity and sex. Geographic location and associated environmental conditions, such as seasonality, stomach fullness, disease and parasite loads, can also affect the value of b (Le Cren, 1951; Bagenal and Tesch, 1978).

The smallest mature male and female in the present study were 11.1 and 11.4 cm long respectively. Lengths at first maturity were 13.4 cm for males and 13.9 cm for females. The difference between the lengths at first maturity of males and females were not statistically significant ($P > 0.05$). Sexual maturity for this species was reported by Suau (1970) at a minimum length of 14.1 cm. It was also reported that this species was mature at lengths of 14 cm (Quéro, 1984) and 13.3 cm (FAO, 1982), which are not considerably different from the results of this study.

The reproductive season extends from the second half of April to early August, with a peak in spawning activity occurring in May. Bauchot and Hureau (1986) reported that this species spawned during spring and summer in the Mediterranean and Atlantic. Suau (1970) observed the same situation in eastern Spanish coastal waters. Grubišić (1982) noted that striped sea bream spawned in summer in the eastern middle Adriatic. Bini (1968) and Tortonese (1975) reported that this species spawned in June and July on the western Adriatic coast. Erzini et al. (1995) reported that striped sea bream spawned between June and August in the south of Portugal.

Length-converted catch curves showed a typical form and justified the estimation of a single value of (Z) for all

fish (Pauly, 1983). The exploitation rate (E = 0.60) is higher than 0.50. Gulland (1971) suggested that as a rule of thumb a fish stock is optimally exploited at a level of fishing mortality that generates E = 0.50, where F_{opt} = M, but in the present study $F>F_{opt}$ = M. More recently Pauly (1987) proposed a lower optimum fishing mortality, F_{opt} = 0.4 M ($F>F_{opt}$). Therefore, the stock of the striped sea bream from İskenderun Bay is being heavily exploited.

There is no information about length at first maturity, fishing size and spawning season or the prohibited season of this species in the fishing circular of the Republic of Turkey Ministry of Agriculture and Rural Affairs (2000). In the light of these results and evaluations, in İskenderun Bay, a minimum size limit should be implemented for *L. mormyrus*. The lengths of fish captured from the bay are smaller than the length at first maturity calculated from the data of the present study. In order to maintain the population in equilibrium, it is of great importance to give each fish the chance to reproduce at least once in its lifetime. Therefore, in the case of the striped sea bream, the minimum fishing size should be 17.0 cm in terms of total length, because the male and female of the species mature at 13.4 and 13.9 cm total lengths respectively (L_m). In addition, fishing should be prohibited from April to August (during the spawning season of this species).

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References

Anderson, R.O. and Gutreuter, S.J. 1983. Length, weight, and associated structural indices. In: Fisheries Techniques (Eds. L.A. Nielsen and D.L. Johnson), American Fisheries Society, Bethesda, pp. 283-300.

Arias, A. 1980. Crecimento, régimen alimentario y reproducción de la dorada (*Sparus aurata* L.) y del robalo (*Dicentrarchus labrax* L.) en los esteros de Cádiz. Invest. Pesq. 44: 59-83.

Bagenal, T.B. and Tesch, F.W. 1978. Age and Growth. In: Methods for Assessment of Fish Production in Freshwaters (Ed. T.B. Bagenal) 3rd ed. IBP Handbook, Blackwell, Oxford, pp. 93-130.

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

Besseau, L. 1990. Etude histo-cytologie de la structure sexuel d'une population de *Lithognathus mormyrus* (L.) (Teléosteen, Sparidé). Rapp. Comm. Int. Mer. Médit. 32: 262 p.

Besseau, L. and Bruslé-Sicard, S. 1991. Sex inversion in a protandric hermophrodite model *Lithognathus mormyrus* L. (1758) (Teleostei: Sparidae): histological peculiarities 95 p. In: Proceedings of the 4th International Symposium on the Reproductive Physiology of Fish (Eds. P.A. Scott, J.P. Sumpter, D.E. Kime and M.S. Rolfe). University of East Anglia, Norwich.

Besseau, L. and Bruslé-Sicard, S. 1995. Plasticity of gonad development in hermaphroditic sparids: ovotestis ontogeny in a protandric species, *Lithognathus mormyrus*. Env. Biol. of Fishes. 43: 255-267.

Beverton, R.J.H. and Holt, S.J. 1957. On the Dynamics of Exploited Fish Populations, U.K. Min. Agr. Fish. Invest. Ser. II, Vol. XIX. H.M.S.O., London.

Bini, G. 1968. Atlante dei pesci delle coste Italiane. Vol. IV. Osteiti. Mondo Sommerso Editrice.

Chilton, D.E. and Beamish, R.J. 1982. Age determination methods for fishes studied by the groundfish program at the Pacific Biological Station. Canadian Special Publications of Fisheries and Aquatic Sciences. Canada.

Chugunova, N.I. 1963. Age and Growth Studies in Fish (Translated). Israel Program for Scientific Translation, Jerusalem.

Düzgüneş, O. Kesici, T. and Gürbüz, P. 1983. İstatistik Metotları, Ank. Üniv. Ziraat Fak. Yayınları: 861, Ankara, (in Turkish).

Erzini, K. Gonçalves, J.M.S. Bentes, L. and Lino, P.G. 1995. Small hook longline selectivity study. Final Report. Commission of the European Communities.

FAO. 1982. Conseil Général des Pêches pour la Méditerranée, Rapport de la premiére Consultation Technique sur l'Evaluation des Stocks dans la Méditerranée Centrale. FAO Rapp. Péches 266, FAO, Rome.

Gayanilo, Jr., FC. Sparre, P. and Pauly, D. 1994. The FAO-ICLARM Stock Assessment Tools (FISAT) User's Guide. FAO Computerized Information Series (Fisheries), No: 6, FAO, Rome.

Grubišić, F. 1982. Ribe, rakovi i školjke jadrana. ITRO Naprijed, Zagreb-GRO Liburnija, Rijeka.

Gulland, J.A. 1971. The Fish Resources of the Oceans. Fishing News Books Ltd., England.

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

Kraljević, M. Dulčić, J. Cetinić, P. and Pallaoro, A. 1996. Age, growth and mortality of the striped sea bream, *Lithognathus mormyrus* L., in the northern Adriatic. Fisheries Research, 28: 361-370.

Kraljević, M. Dulčić, J. Pallaoro, A. Cetinić, P. and Jug-Dujaković, J. 1995. Sexual maturation, age and growth of striped sea bream, *Lithognathus mormyrus* L., on the eastern coast of the Adriatic Sea. J. Appl. Ichthyol. 11: 1-8.

Le Cren, E.D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). J. Anim. Ecol. 20: 210-219.

Livadas, R.J. 1988. 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: 58-76.

Pauly, D. 1983. Some Simple Methods for the Assessment of Tropical Fish Stocks. FAO Fish. Tech. Pap. 234: 1-52.

Pauly, D. 1987. A review of the ELEFAN system for analysis of length frequency data in fish and invertebrates. In: Length-based Methods in Fisheries Research (Ed. D. Pauly, G.R. Morgan). ICLARM Conference Proceedings 13, ICLARM, Manila, 7-34.

Pauly, D. and Munro, J.L. 1984. Once more on the comparison of growth in fish and invertebrates, ICLARM, Fishbyte.

Quéro, J.S. 1984. Les poissons de Mer des Pêches Françaises, Jacques Graucher, Paris.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations, Bull. Fish. Res. Board Can. 191: 203-233.

Ross, S.W. 1988. Age, growth and mortality of Atlantic croaker in North Carolina, with comments on population dynamics. Trans. Am. Fish. Soc. 117: 461-473.

Saila, S.B. Recksiek, C.W. and Prager, M.H. 1988. Basic fishery science programs. A compendium of microcomputer programs and manual of operation. Developments in Aquaculture and Fisheries Science. 18: 1-230.

Secor, D.H. Dean, J.M. and Laban, E.H. 1991. Manual for otolith removal and preparation for microstructural examination. Electric Power Research Institute and Belle W. Baruch Institute for Marine Biology and Coastal Research. USA.

Suau, P. 1970. Contribución al estudio de la biologia *Lithognathus* (= *Pagellus*) *mormyrus* L. especialmente de la sexualidad. Invest. Pesq. 1: 59-66.

Tarım ve Köyişleri Bakanlığı. 2000. Denizlerde ve İç sularda Ticari Amaçlı Su Ürünleri Avcılığını Düzenleyen 2000-2002 Av Dönemine Ait 34/1 Numaralı Sirküler, T.C. Tarım ve Köyişleri Bakanlığı Koruma ve Kontrol Genel Müdürlüğü, (in Turkish) Turkey.

Tortonese, E. 1975. Osteichthyes (Pesci ossei), II. Fauna d'Italia, 11. Ed. Calderini, Bologna.

Willams, T. and Bedford, B.G. 1973. The use of otoliths for age determination. In: Proceedings of the International Symposium on the Ageing of Fish (Ed. T.B. Bagenal). Brothers Ltd., Surrey, England: Unwin Bros, pp. 114-123.

Zore-Armanda, M. 1991. Natural characteristics and climatic changes of the Adriatic Sea. Acta Adriat. 32: 567-586.