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AGE, GROWTH AND MORTALITY OF THE RED PORGY, *PAGRUS PAGRUS*, IN THE EASTERN MEDITERRANEAN SEA (DODECANESE, GREECE)

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AGE
GROWTH
MORTALITY
REPRODUCTIVE CYCLE
RED PORGY
EASTERN MEDITERRANEAN

ABSTRACT – Aspects concerning growth, mortality and reproductive cycle were analysed for red porgy collected in Greek waters. Growth in length, not exhibiting significant differences between the sexes, was expressed for the whole sample with the equation FL = 24.37 + 1.001*S. The application of the back calculation method revealed that red porgy reached 35 % of their maximum size during the first year of life; then growth rates displayed an abrupt decrease. The theoretical maximal length was estimated to be $L\infty$ = 55.7 cm FL. Weight grew isometrically with size for females and allometrically for males. The peak of spawning seemed to occur at the beginning of spring. Length at first maturity (L_{50}) for female red porgy was 31.3 cm FL. The overall sex-ratio was 1 :2.7 in favour of females, while individuals larger than 44 cm were all males. Total and natural mortality were found to be Z = 0.34 $years^{-1}$ and M = 0.22 $years^{-1}$. The exploitation ratio E = 0.37 revealed underfished stock conditions in the studied area.

ÂGE
CROISSANCE
MORTALITÉ
CYCLE REPRODUCTEUR
PAGRE COMMUN
EST MÉDITERRANÉEN

RÉSUMÉ – La croissance, la mortalité et le cycle de reproduction du Pagre commun de Grèce sont étudiés. La relation entre la longueur et le rayon (FL) de l'otolithe (S) est exprimé par l'équation FL = 24.37 + 1.001*S pour l'ensemble des individus. L'application de la méthode du rétrocalcul a révélé que le plus grand pourcentage de la croissance s'observe pendant le premier âge. Les paramètres de l'équation de von Bertalanffy obtenus par la méthode Ford-Walford sont $L\infty$ = 55.7 cm et K = 0.078. L'augmentation du poids en fonction de la taille de la première maturité sexuelle se situe à 30-32 cm. Les femelles prédominaient jusqu'à FL = 44 cm. La mortalité totale Z = 0.34 et la mortalité naturelle, M = 0.22 sont calculées. Le coefficient d'exploitation E = 0.37 indique que la population de Pagre commun de la région étudiée est sous-pêchée.

INTRODUCTION

The red porgy, *Pagrus pagrus*, is a demersal marine fish normally associated with a variety of temperate to subtropical habitats in the Mediterranean Sea, eastern and western Atlantic. This highly prized species, occurring at depths from 20 to 150 m, is usually harvested by a baited hook comprising part of the catches of artisanal fisheries.

The life history of the red porgy in the Mediterranean Sea not hitherto described despite its wide distribution and fishing importance. Our knowledge on the biology and life history of the red porgy has been accumulated from studies on the species of the western Atlantic (Dias *et al.*, 1972; Manooch, 1976; Manooch & Huntsman, 1977; Manooch & Hassler, 1978).

This paper deals with some aspects of growth, estimates the mortality rates and briefly discusses the reproductive cycle of red porgy collected off Kastellorizo Island (Dodecanese, Greece), where it contributes about 5 % of the annual artisanal fish production.

MATERIAL AND METHODS

Fish samples were collected at the stations shown in Figure 1, mainly by hook and line and sometimes in trammel nets. The sampling, totaling

Fig. 1. – Location of sampling stations

151 individuals (137 by hook and line and 14 in trammel nets), took place in April, June, July and October 1985 and in March 1986.

Fork length was measured to the nearest mm and body weight to the nearest gramme. Sex and maturity stage was determined according to Nikolsky's scale (1976). Age classification was based on scales, taken from the left side of the body, beneath the tip of the pectoral fin. Scales taken from each fish were cleaned in 5 % sodium peroxide; their impressions were made by placing several scales from each specimen on a strip of 0.25-inch thick cellulose acetate and applying pressure of 800 Kg/cm^2 at 80 °C with a Carver autopress. Then they were viewed on an Eberbach projector at x32 magnification.

The estimation of the annual growth of red porgy was carried out using the back calculation method based on the scale radius-fork length relationship of 138 specimens. The Von Bertalanffy growth equation ($L_t = L_\infty [1-e^{-k(t-to)}]$) was derived following Ricker (1975). In the above equation, Lt is the length at age t, k is the coefficient of growth, L_∞ is the maximum asymptotic length and to the origin of the curve.

For the estimation of the length at first maturity (L_∞) the regression applied by Gunderson (1977) was used :

ln (P/(1-P) = a + (bxL), where P is the proportion of mature individuals in each size interval and L the mean length of the interval.

Total mortality was calculated by the catch curve method, following Pauly (1983). Other formulae used were :

logM = - 0.0066 - 0.279 log L_∞ + 0.6543 log k + 0.4634 log T, (Pauly, 1983), and E = F/(F + M), (Beverton & Holt, 1957), where M the natural mortality, L_∞ and k the parameters derived from the von Bertalanffy equation, T the mean environmental temperature, F the fishing mortality, and E the exploitation ratio.

RESULTS

Size distribution

Longline and trammel net fisheries had similar modal sizes (Fig. 2A). Since the size of the sample was small, no weighting was used in preparing length-frequency histograms and data from all seasons were combined.

Growth

The analysis of covariance exhibited no difference in the body length-scale radius relationship of the two sexes ($F_{1-123} = 0.843$, $P < 0.05$) and hence the equation derived from the combined sexes was : FL = 24.37 + 1.001*S (r = 0.96), where FL = fork length in mm and S the scale radius *32.

The application of the back-calculation method revealed that young-of the year red porgy attained almost 35 % of their maximum adult size (Table 1). Increment was sharply reduced during the second year (11.9 %), while for the next years, although the reduction continued, it was clearly smoother.

Following Ricker (1975), the parameters of von Bertalanffy's equation were estimated as : L_∞ = 557 mm, K = 0.078 and t_o = 3.558, yielding L_t = 557 x $[1-e^{-0.078(t+3.559)}]$. The theoretical maximal length, 557 mm, is not unrealistic since the largest specimen sampled during the survey was 498 mm.

Length-Weight Relationships

The relation of body weight (g) to fork length (mm) appeared significantly different between the two sexes, when the statistical test of the analysis of co-variance was used ($F_{1-129} = 4.08 > 3.84$, $P < 0.05$). Therefore the regressions computed for each sex are described by the equations : $W = 0.000033 \times L^{2.928}$, (r = 0.98), for the females and $W = 0.000040 \times L^{2.897}$, (r=0.99), for the males. Both equations compare favorably with those obtained by Dias *et al.*, (1972) and Manooch & Huntsman (1976), and reveal that males were slightly heavier than females.

The confidence interval of the slope of the regression of females (c.i = ± 1.96 x standard error) was 2.930 ± 0.104, displaying that weight grew

(a).

Age	N	Observed mean FL	Back - calculated mean fork length at end of year											
			1	2	3	4	5	6	7	8	9	10	11	12	13
13	2	404.0	130.2	177.4	208.4	237.0	263.6	285.2	308.2	326.3	342.3	357.9	372.6	383.7	393.0
12	2	389.5	131.7	177.9	207.9	236.o	261.1	283.2	301.7	319.3	336.4	352.3	366.1	377.4	
11	2	374.5	129.2	176.8	209.9	238.5	263.1	286.1	307.2	326.3	341.8	354.8	364.4		
10	1	359.0	128.7	177.8	211.9	239.0	263.1	286.2	307.2	325.9	343.3	353.4			
9	3	343.0	130.7	176.5	210.3	239.7	265.1	288.2	307.1	324.4	339.3				
8	3	325.6	134.7	178.7	213.9	240.0	265.1	288.5	309.2	324.9					
7	3	307.3	134.7	178.2	210.9	238.0	262.7	283.5	300.5						
6	7	288.7	135.4	181.5	219.4	246.3	271.1	287.1							
5	17	269.4	134.6	181.4	213.5	239.4	263.9								
4	25	249.2	134.5	184.8	218.3	242.8									
3	38	224.5	137.6	185.1	217.3										
2	30	197.4	139.8	184.6											
1	5	163.8	146.1												
Mean FL			136.7	183.4	215.9	241.2	264.9	286.3	305.7	324.4	340.2	354.8	367.8	380.6	393.0
Increments			136.7	46.7	32.5	25.3	23.7	21.4	19.4	18.7	15.8	14.6	13.0	12.8	12.4
% Increments			34.8	11.9	8.3	6.4	6.0	5.4	4.9	4.8	4.0	3.7	3.4	3.3	3.2

(b).

Mean TL	176	258	311	353	385	414	443	455	472	490	511	537	570

Table I. – a, back-calculated fork lengths of red porgy caught off Kastellorizo. b, back calculated total lenghs of reg porgy in the western Atlantic according to Manooch & Huntsman (1977).

isometrically with size ($P < 0.05$). On the other hand, the confidence interval of the males's regression, being 2.897 ± 0.065, had a significant difference from the value 3.0 ($P < 0.05$), implying an allometric growth for this sex.

Reproduction

The final three maturity stages (Nikolsky, 1976) occurred in ovaries from March till June (Fig. 2B). The higher relative frequency of these stages appeared in March and April, suggesting that spawning peaked then.

Length at first at first maturity (L_{50}) coincided with the size interval 300-320 mm. No females smaller than 260 mm and all larger than 360 mm were sexually mature. The only evidence we had concerning males was that, like females, during the spawning period those larger than 360 mm were fully mature. For the estimation of L_{50} of females with greater accuracy the regression applied by Gunderson (1977) was used, yielding $L_{s50} = 312.9$ mm FL. The application of this method to males was not possible, because of the small size of the sample.

Chi-square tests revealed a significant departure from the theoretical 1 :1 sex ratio ($P < 0.05$), when data were stratified by size. The overall sex ratio was 1 :2.7, in favor of females. Individuals larger than 440 mm were all males.

Mortality

A length converted catch curve based on the total catch was used to calculate the total mortality of red porgy (Pauly, 1983). The total mortality, corresponding to the slope of the descending limb of the catch curve, was found to be $Z = 0.34$ years^{-1}.

An empirical estimate of the natural mortality (M) was obtained using Pauly's equation (1983). Inserting in the equation the growth parameters (k, $L\infty$ and the mean environmental temperature of the area (T=16 °C; Theocharis, pers. communication), M was found to be 0.22 years^{-1}. Then, the calculation of fishing mortality gave $F = 0.13$ years^{-1}. Once the values of M and F were available, the exploitation ratio was computed, $E = 0.37$, indicating that the fishing pressure exerted on the red porgy stock in the area under study, was rather light (underfished stock).

DISCUSSION

Estimates of age-at-length for the Dodecanese population of red porgy are compared with those of the species off the Carolina coasts (Manooch & Huntsman, 1978); a considerable variation is exhibited (Table 1). Both estimates were derived from scale reading, where periodic remarks were interpreted to be of an annual nature. Moreover, the growth coefficient of red porgy in Kastellorizo compared with that of the western Atlantic ($k = 0.096$) indicates a relatively slower growth in the eastern Mediterranean waters. It must be noted though that our results are in fork lengths, while those of the western Atlantic in total lengths, which of course does not justify such differences. These variations are attributed to different geographical location, rather than to differences in the methodology employed to derive age data.

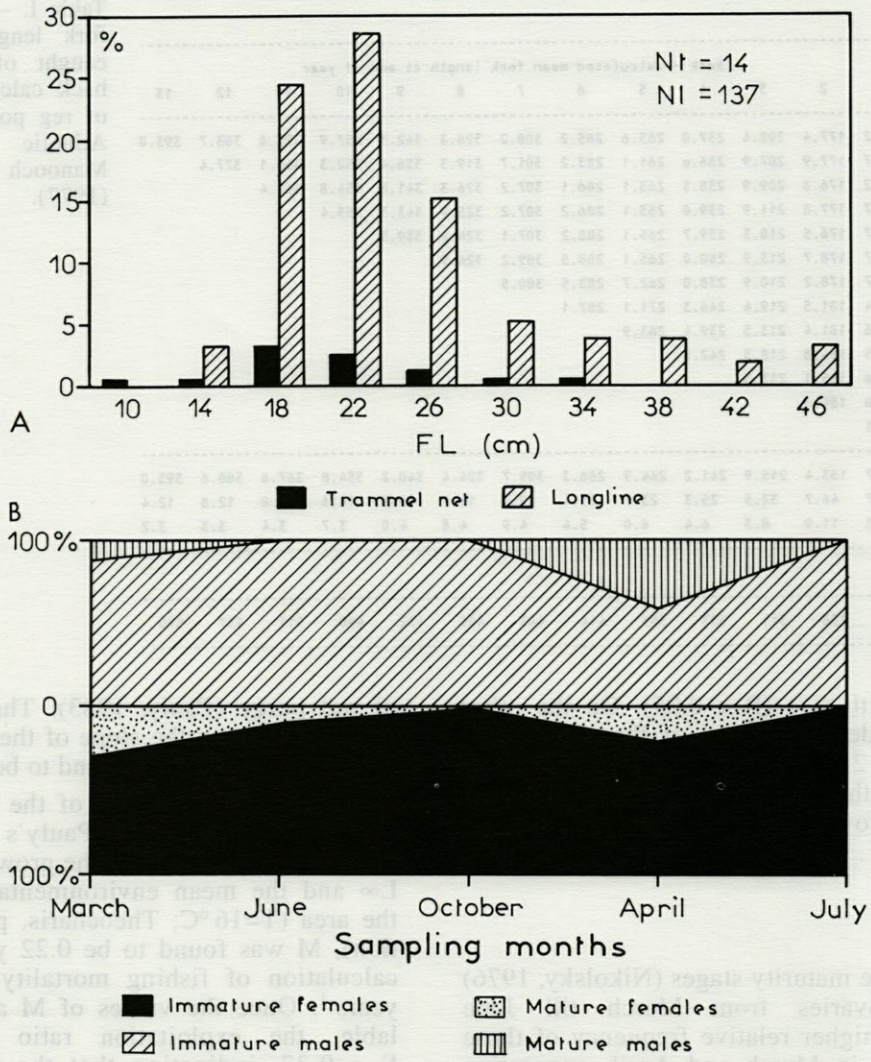

Fig. 2. – A, length frequency distribution of red porgy caught with trammel net and longline off Kastellorizo island from April 1985 to March 1986. B, seasonal percentage of immature and mature male and female red porgy caught off Kastellorizo island from April 1985 to March 1986.

Spawning in red porgy off Kastellorizo island seemed to take place, like in the southwestern Mediterranean (Ranzi, 1969), from spring till early summer. In the western Atlantic spawning occurred during winter months (Ciechomski & Weiss, 1973), extending sometimes till early spring (Manooch, 1976). Thus, a retardation concerning the season of red porgy's sexual maturation existed between the western Atlantic Ocean and the Mediterranean Sea. The length at first maturity (L_{50}) for female red porgy was estimated to be 313 mm FL. Manooch (1976) stated that for female red porgy off the Carolina coasts L_{50} = 304 mm TL, while all fish larger than 364 mm were sexually mature. Alekseev (1983) mentioned that for females off the N.W. African coast the length at which sexual maturation occurred for the first time was 300 mm SL. Hence, it is observed that red porgy reached gonadal maturity at similar size regardless of geographical area.

Sex ratios for red porgy, analyzing data by season and size, were usually in favour of females. Manooch (1976) reported that off the Carolina coast males predominated after 450 mm TL and the overall sex ratio was 1 : 2, while Alekseev (1983) mentioned that male red porgy off Cape Cap-Blan (NW, African coast) predominated after 420 mm SL. The commercial Argentine landings also revealed a predominance of females in the catches (Manooch & Hassler, 1978). The dominance of females for the smaller size classes may be due to protogynous hermaphroditism, existing in the species (Beaumariage in Manooch, 1976; Alekseev, 1983). In our sample, of 151 red porgy, none was found to be hermaphroditic, which is not peculiar considering that Manooch (1976) of the 752 specimens found only 16 to contain both male and female gonadal tissues. Hence, although there was no evidence of hermaphroditism in the red porgy off

Kastellorizo, the theory of protogyny explains adequately the sex-structure of this species.

The mortality rates for red porgy (Z = 0.35, E = 0.37) reflected the exploitation level of the species in the area. Manooch (1976) reported almost similar total mortality (0.32-0.52) for red porgy off the Carolina coasts.

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