SCI. MAR., 62 (3): 289-294 SCIENTIA MARINA 1998

On the fecundity of the Black Sea bream, *Spondyliosoma cantharus* (L.), from the Adriatic Sea (Croatian coast)*

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SUMMARY: The fecundity of the Black Sea bream from the eastern middle Adriatic (Croatian coast) was assessed by the volumetric method using 59 ovaries in pre-spawning stage from fish between 18.5 and 33.5 cm total length. Estimates of total potential annual fecundity varied between 31,670 and 554,070 eggs per female. Relationships between total potential fecundity and total length (TL), total weight (TW) and age (A) were established using the multiplicative regression model. Relative fecundity is constant, reaching a maximum of 850 eggs per g in the 30.5 cm to 31.0 cm length class.

Key words: Fecundity, *Spondyliosoma cantharus*, Adriatic Sea.

INTRODUCTION

Knowledge of fish fecundity is useful in investigating the population dynamics of a fish species and for fish culture purposes. The fecundity-size relationship has been used principally as a rapid means of predicting the fecundity of fish stocks when the length distribution is known.

The black sea bream (*Spondyliosoma cantharus*) is a species that lives in inshore waters on rocky or sandy bottoms and Posidonia beds to depths of 50 m (young) and 300 m (adults). In the eastern Atlantic it occurs from Scandinavia to Angola; Madeira, the Canaries and the Cape Verde Islands (Bauchot and Hureau, 1986). It is very rare in the Black Sea but common in the Mediterranean Sea (Tortonese, 1975) and in the eastern middle Adriatic (Jardas, 1996). In the coastal fishery of Croatia black sea bream form a significant component of the gill net fishery and fish trap catch. Jardas (1996) reported that the catch is around 50 tons per year for the eastern Adriatic coast.

Guerra *et al.* (1993) estimated fecundity of 47 black sea bream from the Saharian Bank (eastern Atlantic), ranging in fork length from 19.8 to 31.4 cm. No other information is available on this species.

This paper presents the first results on the total potential annual fecundity (here considered as the total number of developing oocytes potentially capable of being released in the current spawning season) of black sea bream from the Adriatic Sea in relation to total length, total weight and age.

*Received February 12, 1997. Accepted April 4, 1998.

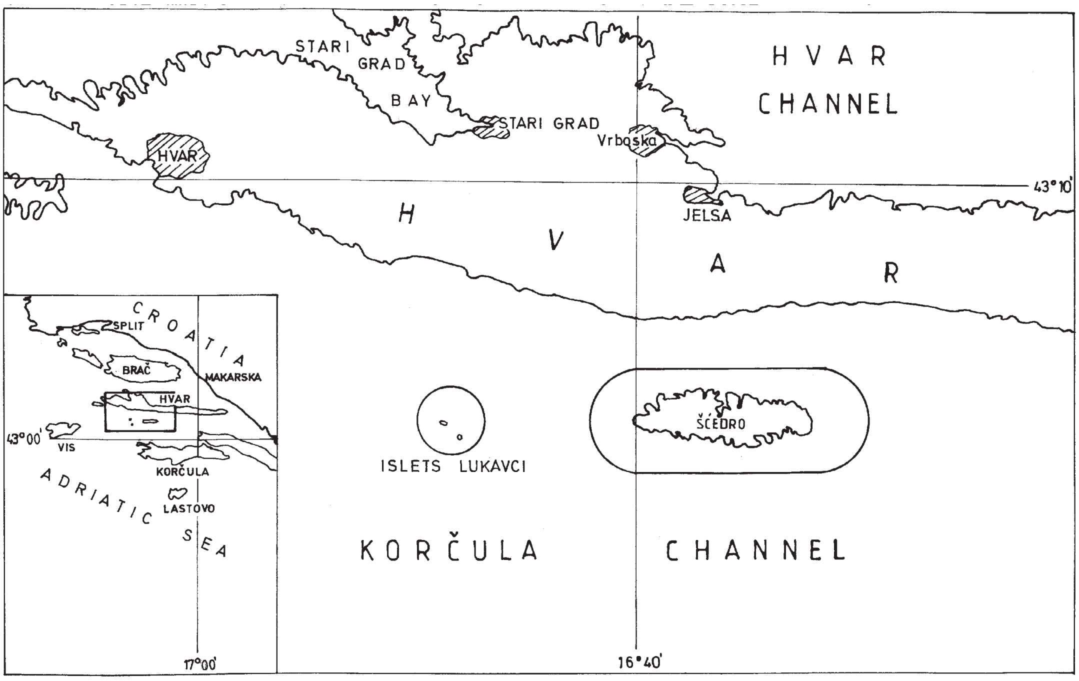

FIG. 1. – Sampling area (islets Lukavci and island Scedro, eastern middle Adriatic).

MATERIALS AND METHODS

During March and April 1994 (from 28 March to 2 April) samples of black sea bream were caught by gill-net at islets Lukavci and island Scedro south from island Hvar in the eastern middle Adriatic (Fig. 1). From these samples, a total of 78 females with ovaries in pre-spawning stage (ovaries yellow or orange in colour and presenting large opaque oocytes) were selected.

In the laboratory all individuals were measured to the nearest 0.1 mm total length and weighed to the nearest 1.0 g total weight. For age determination scales were taken from both sides down the lateral line in an area, below the tip of the pectoral fin, cleaned in 5% sodium peroxide and viewed using a binocular microscope at 40x and 60x magnification.

From the inital 78 ovaries, 59 were weighed to the nearest 0.1 g, split open longitudinally and immersed in Gilson's fixative (Simpson, 1951) for 2-3 months. To allow a better penetration of the fixative and to make the membrane breakdown easier the ovaries were frequently shaken. The remaining ovaries were placed in a solution containing 10 v. 50% alcohol, 5 v. formol 40% and 2 v. glacial acetic acid for 48 h and then transferred to 70% alcohol. After embedding in paraffin wax, sections were cut at 7 μm and stained with haematoxylin and eosin.

Observations of the histological sections of the 19 ovaries allowed us to establish the criterion used for total potential fecundity estimates. Following Walsh *et al.* (1990), the criterion was based on the presence of vitellogenesis. Therefore the percentage of non-vacuolated (small previtellogenic oocytes with no cytoplasmic vesicles) and vacuolated oocytes (oocytes in which perinuclear cytoplasmic vescicles have appeared and vitellogenesis begins) in relation to their diameter was determined by measuring and counting those oocytes sectioned through the nucleus. Following Macer (1974) the size at which 50% of oocytes showed signs of vacuolation was considered as the size threshold for use in the total potential fecundity calculations. Furthermore, the histological sections allowed us to quantify preovulatory atresia and to obtain the size frequency distribution of the oocytes.

For fecundity estimates the volumetric method was employed. The ovaries were removed from Gilson's fluid, placed in a beaker with a known volume of water and mixed with a magnetic stirrer. Five subsamples were obtained from the ovaries of each fish using a 1 ml Stempel pipette and subjected to an analysis of variance to test their homogeneity.

To establish the relationship between total potential fecundity (F) and total length (TL), total weight (TW) and age (A), the multiplicative ($y = ax^b$) regression model was used.

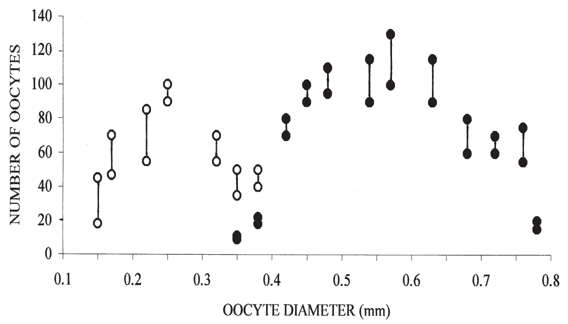

FIG. 2. – Mean number ±2 SE of non-vacuolated (m) and vacuolated (l) oocytes in 19 black sea bream ovaries.

RESULTS

To establish a relationship between vacuolated and non-vacuolated oocytes, an average of 1,160 oocytes per ovary was measured. The results, presented in Fig. 2, show that 350 μm oocyte diameter marks the beginning of vacuolation and that not vacuolated oocytes greater than 800 μm were present in pre-spawning ovaries. Furthermore, plotting the number of vacuolated oocytes in relation to the total number of oocytes in each ovary against oocyte diameter, resulted in a 50% size threshold value of 500 μm. No empty follicles were recorded indicating that the spawning season had not yet begun.

Table 1 presents the results of the total length, weight, age and total potential fecundity estimates for each of the 59 individuals sampled.

Analysis of variance of the subsamples taken from both ovaries of each fish showed no significant differences (F=2.68; $F_{0.5,1,\infty}$= 3.84). A mean total potential fecundity per fish was thus obtained; between 31,670 eggs belonging to a 18.5 cm female, and 554,070 eggs corresponding to a 32.5 cm female were recorded (Table 1).

Table 2 and Fig. 3. show the relationships between total potential fecundity and total length, total weight and age obtained from the application of the multiplicative regression model.

The trend of relative fecundity (recorded as the number of eggs per gram of body weight) is shown in Fig. 4. Relative fecundity appears constant, reaching a maximum of 850 eggs per g in the 30.5 cm to 31.0 cm length-class.

TABLE 1. – Size (TL, cm), total weight (TW, g), age (years), total potential fecundity (F) (number of eggs), and ovary weight (OW, g) obtained in each of the 59 individuals sampled.

F	TL	TW	OW	Age	F	TL	TW	OW	Age
36820	18.5	70	5.3	2	240040	26.2	316	22.1	4
31670	18.5	63	4.1	3	229950	27.0	365	27.7	4
54000	19.0	85	7.5	3	217510	27.0	412	32.3	5
50360	19.0	96	8.9	3	233940	27.0	405	40.0	4
64970	19.5	125	8.6	3	328190	27.8	432	32.1	4
63510	19.5	112	8.1	3	317650	27.8	380	43.1	4
65200	20.5	153	9.3	3	329960	28.0	432	39.2	5
68710	20.5	140	14.0	3	340910	28.5	390	47.3	5
93880	21.2	162	12.5	3	300420	28.5	450	42.7	4
87420	21.5	159	11.4	3	307330	28.5	350	39.3	5
83150	21.9	165	14.2	3	329000	28.5	410	61.3	4
97090	22.0	163	10.3	3	395440	29.5	435	52.7	5
88330	22.0	154	13.2	3	320620	29.5	465	66.3	4
93230	22.5	196	15.4	3	381360	30.0	490	64.3	5
107220	22.5	184	15.9	3	427420	30.0	520	58.2	5
121360	22.6	213	12.7	3	458920	30.5	562	60.1	5
100640	23.0	205	14.0	4	479000	30.5	570	52.0	5
116290	23.0	230	16.6	3	433120	31.0	562	63.3	5
120760	23.5	210	16.0	4	463750	31.0	580	61.7	5
119720	23.5	250	15.3	3	472660	31.5	597	73.2	6
120460	24.0	235	17.1	4	467680	32.0	707	70.0	6
142670	24.5	268	17.3	4	450600	32.0	620	66.9	6
120450	24.5	258	18.2	3	420190	32.1	628	73.9	5
168430	24.5	270	17.9	4	554070	32.5	560	80.1	6
163970	25.5	310	20.4	4	507790	32.5	670	84.3	5
180520	25.5	297	17.1	4	500320	32.5	700	87.3	6
142360	25.5	302	23.2	4	456960	33.0	740	92.1	6
200250	26.0	360	25.2	4	480730	33.0	715	89.3	7
297630	26.0	393	23.3	4	462330	33.2	720	93.1	6
					452910	33.5	740	92.3	7

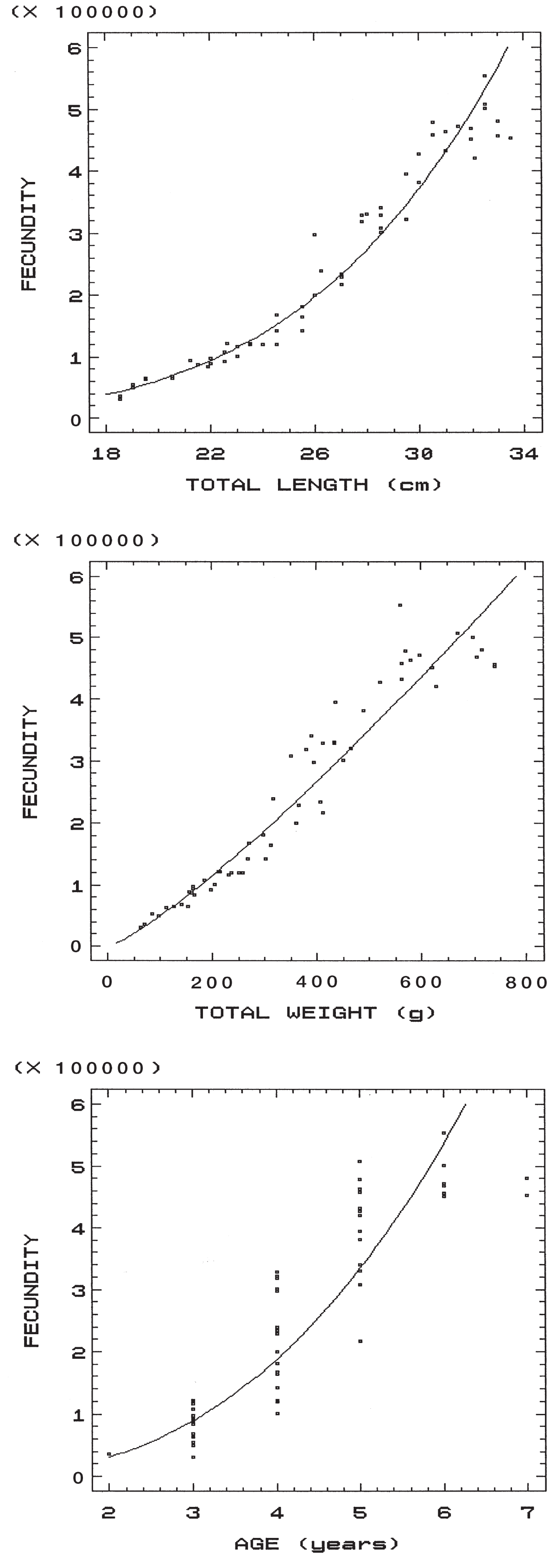

FIG. 3. – Relationship of total potential fecundity to total length, total weight and age (multiplicative model).

TABLE 2.– Relationships between total potential fecundity (F) and total length (TL), total weight (TW) and age (A) obtained from the application of multiplicative regression model.

	Multiplicative	
F/TL	$F = 0.1052TL^{4.434}$	r^2=0.9688
F/TW	$F = 193.23TW^{1.207}$	r^2=0.9590
F/A	$F = 5179.635A^{2.58981}$	r^2=0.8065

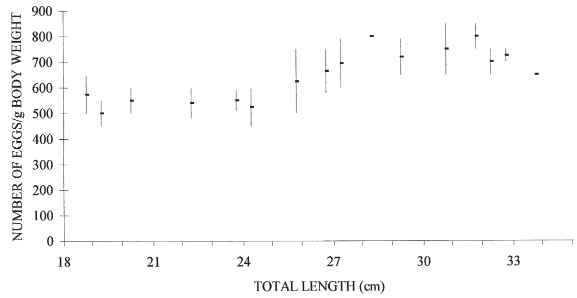

FIG. 4. – Development of relative fecundity (expressed as mean number of eggs ±SD per g body weight) in relation to total length.

DISCUSSION

Annual fecundity of a population is of biological interest. Its modulation is a contributor to population homeostasis, and the large variations seen from year to year, and over decades, reflect the amelioration or deterioration of the habitat in relation to the individual fish (Nikolskii, 1969). Its measurements is also of practical importance. For some commercially valuable fish stocks estimation of abundance and subsequent catch quotas, cannot be based upon the usual fisheries data of catch at age and effort; this may be because fish cannot be aged, catch data are unreliable, or because the relationship between catch rate and stock size is unknown. In these cases it is sometimes possible to estimate abundance from planktonic egg surveys and individual fecundity (Lockwood *et al.*, 1981); this has been termed the "total fecundity" method. Plankton surveys, covering the spawning area and period, give the total number of eggs produced by the stock, and the number, or biomass, of spawning fish is found by dividing total eggs produced by the average individual fecundity or eggs per unit weight.

Both protandrus and protogynous hermaphroditism are relatively common among the Sparids

TABLE 3. – Absolute fecundity for other sparid species presented by other Authors.

Species	Author	Absolute fecundity	Studied area
Pagellus bogaraveo	Krug (1990)	73000-1500000	Azores
Boops boops	Larrañeta (1953)	35000-150000	Spanish Mediterranean
Boops boops	Girardin (1981)	80000-400000	Bay of Lions
Pagellus erythrinus	Papaconstantinou *et al.* (1986)	22200-362200	Greek seas
Pagrus caeruloestictus	Chakroun-Marzouk and Kartas (1987)	1368-823430	Tunisian coast

(D'Ancona, 1949, 1956). Black sea bream collected from the eastern Adriatic appear to display protogynous hermaphroditism (Jardas, 1996). At first, each fish functions as a females, after which the ovaries begin transforming into testes. The predominance of females in the smaller length classes (13.0-36.0 cm) and the presence of one individual (18.4 cm) with both ovaries and testicular tissues supports the theory of protogyny.

No post-ovulatory follicles were recorded in any of the 59 specimens sampled, indicating that the spawning season had only just begun. According to Bauchot and Hureau (1986) the spawning season of black sea bream is between February and May depending on the area. Dulčić (1992) found that the peak of the spawning season of the black sea bream along the eastern middle Adriatic coast is between April and May. The size-frequency distribution of the oocytes showed that oocyte size classes are countinously distributed in the ovary, indicating the existence of indeterminate fecundity in the black sea bream. In comparing vacuolated and non-vacuolated oocyte diameter, we recorded no distinct hiatus. Sizes of the two stages of oocytes overlapped between 300mm and 400mm. This also contributed to our conclusion that the species is probably an indeterminate spawner. Mutiple spawning is considered to be a reproductive strategy typical of subtropical and tropical fish (Burt *et al.*, 1988), probably to take advantage of environmental conditions favourable for larvae survival and recruitment. According to Hunter and Macewicz (1985) and Hunter *et al.* (1985), this fact should be enough to consider batch fecundity (number of eggs produced in a single spawning batch) as the only useful measurement in estimating annual fecundity (in this case considered as a function of both the batch fecundity and the number of spawnings per year). Fecundity is easily measured in determinate spawners, but it is difficult or impossible to measure in indeterminate spawners. In the latter case, estimates of population abundance have been obtained by using the "batch fecundity" method (Hunter and Goldberg 1980). This estimate is calculated from synchronous, daily measurements of planktonic egg production divided by the number of eggs spawned per fish (the batch size) and the proportion of fish spawning on that day. The method is not universally applicable because of problems associated with migration of fish through spawning grounds, asynchrony of daily spawning and the difficulty in ageing post ovulatory follicles. According to the final report from the I.C.E.S. C.M. Workshop for mackerel (*Scomber scombrus*) and horse mackerel (*Trachurus trachurus*) egg production (Anonymus, 1993) which pointed out that both methods (batch fecundity and total potential annual fecundity) can be made to work satisfactorily and due to the fact that we had no possibility to carry on the batch fecundity method, we were forced to use the total potential annual fecundity method to calculate the fecundity of the black sea bream. To estimate the minimum size of the oocyte, the criterion of the presence of cytoplasmic vacuoles was choosen. As Macer (1974) points out, when there is no clear size separation between resting and developing oocytes, the oocyte diameter distribution associated with the examination of histological sections should be used to establish the criterion of whether an oocyte is resting or will develop in the current season. That criterion uses a smaller oocyte size when compared with criterion based on the presence of yolk granules used by Rao (1971). We think that further studies are needed to use the "batch fecundity" method in order to elucidate the annual fecundity of black sea bream.

To compare our fecundity estimations with those of Guerra *et al.* (1993) is not feasible owing to the different methodology used (e.g. size range sampled, oocyte size threshold, different oocytes size range). Guerra *et al.* (1993) found that the total number of eggs per female ranged from 36,926 to 143,900 (average 65,659) and the oocyte diameter ranged from 0.55 to 1.17 mm (average 0.906 mm) for the black sea bream from the Saharan Bank (eastern Atlantic). Specimens from the Saharan bank were collected during the spawning season. Wilson (1958) found that the average diameter of already spawned eggs of black sea bream in Plymouth laboratory was around 1 mm. The total number of eggs per female found in this study ranged from 31,670 to 554,070 and the oocyte diameter observed was from 0.20 to 0.80 mm.

The relationship fecundity vs. age could be explained by the fact that the black sea bream is a protogynous hermaphrodite, and the change of sex in the Adriatic fish takes place between 7 and 8 years of age (Dulčić *et al.*, unpublished data). Due to this change, still-existing females at 7 years old have relatively fewer eggs in their ovaries, as the sexual apparatus is changing its physiology.

There are few references and data on fecundity of other sparid fish (Table 3). From the data presented it is obvious that the values of relative fecundity oscillate considerably depending on the species and geographical location.

ACKNOWLEDGEMENTS

We thank the family Bibić from the island of Hvar for their help in collecting the material.

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