



Mediterranean Marine Science

Vol 4, No 1 (2003)



Growth, Mortality And Yield Per Recruit Of Bogue, Boops Boops (L.), From The Egyptian Mediterranean Waters Off Alexandria

S.M. ALLAM

doi: 10.12681/mms.244

To cite this article:

ALLAM, S. (2003). Growth, Mortality And Yield Per Recruit Of Bogue, Boops Boops (L.), From The Egyptian Mediterranean Waters Off Alexandria. *Mediterranean Marine Science*, *4*(1), 87–96. https://doi.org/10.12681/mms.244

Mediterranean Marine Science

Vol. 4/1, 2003, 87-96

Growth, Mortality And Yield Per Recruit Of Bogue, *Boops Boops* (L.), From The Egyptian Mediterranean Waters Off Alexandria

S. M. ALLAM

National Institute of Oceanography and Fisheries, Kayet Bay, Al-Anfoushy, Alexandria, Egypt e-mail: allamsm@hotmail.com

Abstract

Age and growth of Boops boops (L.) from the Mediterranean Sea off Alexandria were estimated from scales. No significant difference in growth was found between male and female. Back-calculated lengths at annulus formation for combined sex were 10.97, 14.03, 16.39, 18.56 and 20.51cm TL. The estimated von Bertalanffy growth parameters were $L_{\infty} = 31.68$ cm, K = 0.1531 year⁻¹ and $t^* = -1.7838$. The length-weight relationship was $W = -2.1548L^{3.1031}$. Total mortality (Z), natural mortality (M) and fishing mortality (F) were 1.283, 0.458 and 0.824 year⁻¹ respectively. The exploitation rate (E) was 0.464. A Beverton-Holt yield-per-recruit model indicated that the maximum yield-per-recruit was 21.06 g when fishing mortality was 2.4 and the current fishery harvests approximately 95% of the potential yield.

Keywords: Boops boops, Mediterranean, growth, mortality and yield-per-recruit.

Introduction

Boops boops is a demersal or semipelagic species inhabiting inshore waters above various bottoms (sand, mud, rocks or posidonia beds) in the whole Mediterranean, eastern and western Atlantic (BAUCHOT & HUREAU, 1986). In the eastern Atlantic (from British Isles to Angola) *Boops boops* forms schools far from the coast at the surface (at night) or down to 200 m, normally above 100 m (BRAVO DE-LAGUNA, 1982).

Off Alexandria coast, *Boops boops* is one of the most abundant species caught mainly in purse seine net ("shanshoulla") (HASSAN, 1990). It constitutes 9.92 % of the total commercial catch landed at Alexandria (ALLAM *et al.*, 1998).

In the Mediterranean Sea, age and growth of bogue, *Boops boops*, have been studied by ANATO & KTARI (1986) along the Tunisian coast, HERNANDEZ (1989) in the Central Adriatic Sea and HASSAN (1990) along the Egyptian coast, from Rashid to Salloum, while length-weight relationship was studied by BOTROS *et al.* (1985) in western Libyan and STERGIO & MOUTOPOULOS (2001) in Greece. GONÇALVES *et al.* (1997) studied the length-weight relationship of *B. boops* and other demersal fish along the south coast of Portugal. The present study aimed to model age and growth of *Boops boops* off Alexandria and to estimate growth performance, mortality parameters, exploitation rate and yield-perrecruit in order to evaluate the state of this fish stock.

Materials and Methods

Individuals of Boops boops were collected from the commercial catch of purse seine net ("Shanshoulla") landed at Alexandria during the period from March to December 1999. For each fish, sex, maturity stages, total length (cm), total and gutted body weight (g) were recorded. Scales were removed from under the pectoral fin of the left side of the fish, cleaned and viewed with low-power microscope (16 X). Scale radius and distance from focus to each ring were measured with an ocular micrometer. Mean values of scale radius were calculated for each 1-cm length group. The scale radiustotal length relationship was determined by least square method. Correction for backcalculated fish length-at-each year of life were calculated by Lee formula:

$$L_n = S_n (TL - a) / S + a$$

where L_n is the length (cm) at age 'n', TL is the total fish length (cm), Sn is the radius of annulus 'n', S is the scale radius and a is the intercept of the regression line. Mean observed length-at-age and back-calculated lengths were computed. Length-weight relationships were determined using the formula

where W is weight (g), L is total length (cm), b is the length-weight factor and a is a constant. The von Bertalanffy growth model was fitted to back-calculated length–at-age. The model was of the form:

$$L_t = L_{\infty} (1 - e^{-k(t - to)})$$

where L_t = length at time t (years), L_{∞} = theoretical maximum length (cm), K = growth

coefficient and t° = theoretical time at which L = 0. The values of all growth parameters (L_{∞} , K and t°) were estimated according to GULLAND (1964).

In order to compare different estimations of growth parameters, the empirical equation of growth performance,

$$\emptyset = \log_{10} k - 2 \log_{10} (L_{\infty}),$$

of PAULY & MUNRO (1984) was used. Maximum age (tmax) was estimated after PAULY (1983) as:

$$t_{max} = 3 / k + t_0.$$

Mortality rate (Z) was calculated from the catch curve as described in Ricker (1975). Natural mortality coefficient (M) was estimated from the equation of PAULY (1980) as follows:

$$Log M = -0.0066 - 0.279 \log 10 L_{\infty} + 0.6543 \log_{10} K + 0.4634 \log_{10} T$$

where L_∞ and K are the parameters of the von Bertalanffy growth model and T is the mean water temperature, here set at T = 21.65 °C (MAIYZ & SAID, 1988). The difference between total mortality coefficient (Z) and the natural mortality coefficient (M) gave an estimate of fishing mortality (F):

$$\mathbf{F} = \mathbf{Z} - \mathbf{M}.$$

Survival rate (S) was estimated from the equation $S = e^{-z}$ (RICKER, 1975). According to CUSHING (1968), the rate of exploitation $E = F^*A / Z$ where F and Z are fishing and total mortality and A = 1 - S.

Length at first capture (L_c) was determined using BEVERTON & HOLT (1957) equation of L_c = L⁻ - K (L_{∞} - L⁻) / Z, where L_c is the length at first capture, L⁻ was the mean length of fish in the catch sample, K and L_{∞} are parameters of the von Bertalanffy growth equation and Z is the instantaneous mortality rate. The corresponding age at first capture (t_c) was calculated as

$$t_c = -1/K \log 10 (L_{\infty} - Lc / L_{\infty}) + t_o.$$

The BEVERTON & HOLT (1957) model of yield-per-recruit was estimated according to GULLAND (1969) as follows:

$$\begin{split} Y/R &= F(e^{-M(tc-tr)}) \\ & W_{\infty} \{1/Z - 3S/(Z+K) + \\ & + 3S^2/(Z+2K) - S^3/(Z+3K)\}, \end{split}$$

where Y/Z is yield-per-recruit, F is the fishing mortality coefficient, M is the natural mortality coefficient, t_c is the mean age at first capture, t_r is the mean age at recruitment, W_{∞} is the asymptotic weight, Z is the total mortality, K is the growth coefficient and

$$S = e^{-K(tc-to)}$$

Results

Age and growth

The frequency distribution of age reading for all *Boops boops* is given in table 1. Boops boops population ranged in age from 1 to 5 years. The majority of fishes were found to belong to 2 and 3 years old (33.25 % and 37.06 %). Fishes of 5 years old contributed only 2.85 %.

The relationship between scale radius and total fish length was found to be linear (Fig. 1). No significant difference was found in this relationship between male and female (F = 0.55 at df_{1,20}, P > 0.200). Therefore this



Fig. 1: Scale radius – total length relationship of *Boops boops*.

Fish length		Num	Number of fish at age (years)			Total nun	ıber
group (cm)	1	2	3	4	5		
11	16					16	
12	18					18	
13	9	6				15	
14	2	43				45	
15		61	6			67	
16		21	57			78	
17		9	45	8		62	
18			40	14		54	
19			6	39	1	46	
20			2	7	3	12	
21					6	6	
22					2	2	
Total number	45	140			156	68	
12	421						
Percent	10.69	33.25	37.06	16.15	2.85	-	
Mean length	12.02	14.79	16.82	18.57	20.58	16.02	
S.D.	±0.87	±0.96	±0.99	±0.89	±0.90	±2.23	

 Table 1

 Frequency distribution of age readings of *Boops boops*.

relationship was computed for combined sex as L = 3.163 + 3.863S ($r^2 = 0.986$, n = 292). The intercept of this equation (3.163) was used as a correction factor in back-calculated lengthat-end of each year of life (Table 2). Since the back calculated length-at-age for males and females were nearly equal (Table 2), the sexes were pooled. *Boops boops* grew to 10.97 cm TL in the first year of growth, reaching a maximum length of 20.51 cm in the fifth year (Table 2). The maximum growth rate was in the first year (53.49 %) and then decline with age. Length-weight relationship was highly correlated with coefficients ranging from 0.996 for females to 0.982 for males (Fig. 2). In spite of the rate of putting in weight for females was slightly higher than that of males for the same length group, the analysis of co-variance revealed a highly insignificant difference between them (F = 0.2 at df_{1,20} P>0.200). Sexes were therefore pooled and the regression representing this relationship was described by W = -2.1548 TL^{3.1031} (r² = 0.996, n = 421). The weight of fish at different ages was determined by using length-weight equation.



Fig. 2: Length (L) – weight (W) relationship of males and females of Boops boops.

	Table 2			
Back-calculated and theoretical leng	gth and weight	of Boops boo	ps at different	years.

			Age (years)		
	1	2	3	4	5
Males					
Number	4	13	21	12	2
Mean back-calculated length(cm)	10.74	14.03	16.45	18.41	20.90
Females					
Number	11	29	33	18	5
Mean back-calculated length(cm)	11.06	14.03	16.35	18.66	20.35
Combined sex					
Number	15	42	54	30	7
Mean back-calculated length(cm)	10.97	14.03	16.39	18.56	20.51
Theoretical Length (cm)	10.99	13.93	16.45	18.61	20.46
Back-calculated weight (g)	12.28	25.79	41.39	60.48	81.90
Theoretical weight (g)	12.27	25.2	41.85	60.94	81.38

The rate of putting on weight was minimal in the first year (14.99 %) and then increased as the fish got older reaching maximum increment at fifth year (26.15 %; Table 2).

The von Bertalanffy growth equation describing *Boops boops* growth in length was:

$$TL t = 31.68 (1 - e^{-0.1531(t + 1.7838)})$$

The length-at-age calculated form this equation was close to the back-calculated length (Table 2). The length-weight relationship was used to convert the asymptotic length ($L_{\infty} = 31.68$ cm TL) to the corresponding asymptotic weight (315.3 g). The von Bertalanffy equation for growth in weight was described by the following equation:

$$Wt = 315.3 (1 - e^{-0.1531(t + 1.7838)})^{3.1031}$$

The theoretical weight-at-age and backcalculated weight agrees closely (Table 2).

The maximum theoretical age attained by this fish species was 17.81 years. The growth performance was estimated as $\emptyset = 2.19$.

Mortality and exploitation rate

The instantaneous total mortality coefficient (Z) was estimated from the catch curve as 1.283 (Fig. 3). The natural mortality (M), fishing mortality (F) and annual mortality (A) were estimated to be M = 0.458, F = 0.824 and A = 0.722 year⁻¹. The exploitation rate was estimated as E = 0.464.

Length and age at recruit and first capture

The length at recruitment (Lr) was graphically determined from the cumulative curve of recruit proportion at different length (Fig. 4). The length obtained was Lr = 11.7 cm. The corresponding age was tr = 1.23 year. The mean length of the commercial catch was estimated as 16.02 cm TL for fishes ranging from 11 to 22 cm TL (Table 1). Consequently, the length at first capture was estimated as Lc = 14.15 cm TL and the corresponding age (T_c) was 2.08 years.

Yield-per-recruit

The yield-per-recruit of *Boops boops* (Fig. 5) increases rapidly as the fishing mortality



Fig. 3: Catch curve of Boops boops.



Fig. 4: Cumulative curve of recruit proportion at different lengths of *Boops boops*.



Fig. 5: Yield-per-recruit of Boops boops.

increases reaching a maximum value (MSY/R = 21.06 g) at a fishing mortality F = 2.4, after which the yield-per-recruit was more or less stable with further increase in fishing mortality. At the present level of fishing mortality (F = 0.824), age of first capture ($T_c = 2.08$ year), and natural mortality (M = 0.458), the current yield-per-recruit (CY/R) was estimated to be 19.92 g.

Discussion

Boops boops attain their maximum size slowly (K= 0.1531) and have a long life span (17.8 years). These estimates agree with that of HERNANDEZ (1989) who gives a maximum age of 16.6 years for *B. boops* in the Central Adriatic Sea.

Five years were separated in the present study. The mean length-at-age values estimated by different authors are represented in Table 3. The length-at-age for 1 to 5 years obtained in the present study are very similar to that obtained in 1977-1978 for *B.boops* caught from Rashid to Salloum (HASSAN, 1990). The absence of fishes of six-years old in the present study was mainly due to disappearance of larger fishes from the catch (from 22 to 25 cm TL) and also to sampling locality. The lengthat-age, however varied from various localities (Table 3). The variability in growth of *B. boops* may result from several factors including differences in mortality rates, environmental conditions or genetic variations (DUTKA-GIANELLI & MURIE, 2001).

Boops boops grew quickly in length during the first year of life reaching 53.49 % of its final growth; this was followed by a reduced growth rate that coincided with sexual maturity (one year for both males and females). EZZAT *et al.* (1992) stated that during the first year of life most of food consumed is used for growth in length while at sexual maturity food is used for maintenance of gonad formation and growth in weight. Therefore, the increment in weight of *B. boops* was slower in the first year of life then increased to reach its maximum value at 4 and 5 years old (23.31 and 26.15 %).

The length-weight relationship of Boops boops shows a positive allometric growth. The same growth was observed for B. boops in western Libya (BOTROS et al., 1985) and in central Adriatic Sea (HERNANDEZ, 1989). The parameters of length-weight relationship estimated in the present study fall within the result of the previously reported values in other localities (Table 4). The length-weight relationship given by HASSAN (1990) was based on gutted body weight. For comparison, length-gutted body weight relationship was computed in the present study. The factor (b) of this equation (3.2249) was greater than the value of 2.8306 recorded in 1977-1978 (HASSAN, 1990). On the other hand, the

	Anato &Ktari, 1986.	Hernandez, 1989.	Hassan, 1990.	Present study			
Age	Tunisian coast	Central Adriatic	Egyptian coast	Off Alexandria			
(Years)	Scales & Otoliths	Otoliths	Scales	Scales			
	SL (TL)*	TL	TL	TL			
1	7.67 (10.24)	-	10.16	10.97			
2	9.79 (12.78)	14.73	13.29	14.03			
3	13.02 (16.63)	17.53	15.93	16.39			
4	15.62 (19.73)	20.04	18.27	18.56			
5	16.74 (21.07)	22.03	20.24	20.51			
6	18.99 (23.76)	23.80	21.65	-			
7	20.19 (25.19)	-	-	-			
8	21.10 (26.27)	-	-	-			
* $SL = 0.838 TL - 0.9172$, given by these authors							

 Table 3

 Mean length-at-age of *Boops boops* given by various authors.

Locality	Δ	P	No	Langth range	Source		
Locality	A	D	INO	Length Tange	Source		
Egyptian coast from	-1.844	2.8306*	2609	8 – 25 cm TL	Hassan,1990		
Rashid to Salloum							
Western Libya	-2.1554	3.1125	-	-	Botros et al.,1985		
Tunisian coast	0.02423	2.8874	785	8 – 22 cm TL	Anato &ktari, 1986		
				(=10.6 - 27.4 cm TL)			
Greece	0.0149	3.093	256	9.6 24.3 cm TL	Stergiou &		
					Moutopoulos, 2001		
Central Adriatic Sea	6.44×10^{-5}	3.113	165	12.8 – 23.0 cm TL	Hernandez, 1989		
Spanish coast of	0.0082	3.0	228	12.4 -26.6 cm TL	Merella et al.,1997		
Western Mediterranean							
South coast of Portugal	0.0083	3.037	603	15.8 – 35.3 cm TL	Gonçalves et al., 1997		
Egyptian coast off Alexandria	-2.1548	3.1031	435	10.5 – 22.4 cm TL	Present study		
	-2.3373	3.2249*	435	10.5 – 22.4 cm TL			
* Calculations based on gutted weight							

 Table 4

 Comparison of length -weight parameters for combined sex of *Boops boops* from different localities.

gutted body weight-at-length in the present study was lower than the corresponding value given in 1977-1978, but the difference was not significant.

The asymptotic length of 31.68 cm estimated for *Boops boops* was considerably greater than the maximum observed length of 22.4cm and 26cm TL reported before in 1977-1978 (HASSAN, 1990). The maximum length of B. boops recorded was less than that value recorded in other localities (Table 5). BAUCHOT & HUREAU (1986) assigned a maximum length of 36 cm to *B. boops* from the whole Mediterranean Sea.

The von Bertalanffy growth parameters of *Boops boops* reported by various authors are

shown in Table 5. The growth coefficient (K) was generally low, ranging from 0.1107 to 0.1779 per year and the asymptotic length ranged from 29.97 to 39.6 cm TL. It can be concluded that the growth pattern of *B.boops* from the Egyptian Mediterranean coast off Alexandria appears to be smaller than that of *B. boops* population inhabiting western Mediterranean Sea.

The estimate of growth performance $(\emptyset = 2.19)$ showed best agreement with the value obtained in 1977-1978 ($\emptyset = 2.20$; HASSAN, 1990). Also, this value lies within the corresponding values in other localities (Table 4).

Table 5
Comparison of von-Bertalenffy growth parameters, maximum length, Growth performance (\varnothing)
and aging method for combined sex of <i>Boops boops</i> from different localities.

Locality	\mathbf{L}_{∞}	K	То	Max.	Ø	Aging	Source
				length		method	
Egyptian coast, from	29.79 cm TL	0.1779	-1.3323	26 cm TL	2.2	Scales	Hassan,
Rashid to Salloum							1990
Tunisian coast	32.27 cm TL	0.1107	-1.6882	22 cm TL	2.07	Scales &	Anato &
	$(= 39.6 \mathrm{cm TL})$					otoliths	Ktari,1986
Central Adriatic Sea	33.89 cm TL	0.167	-1.296	25 cm TL	2.28	Otoliths	Hernandez,
							1989
Egyptian coast off	31.68 cm TL	0.1531	-1.7838	22.4 cm TL	2.19	Scales	Present
Alexandria							study

The mean observed length of the commercial catch of *Boops boops* (16.02cm) was lower than that value obtained in 1977-1978 (17.26 cm; HASSAN, 1990). The decreasing in the mean length may be due to disappearing of larger fish from the catch (from 22 to 25 cm) and different fishing areas.

At the present level of fishing mortality (F = 0.824), age at fish capture (T_c = 2.08 year) and natural mortality (M = 0.458), the current yield-per-recruit (CY/R) was estimated to be 19.92 g. This means that the level of fishing mortality (F = 0.824) was greatly lower than that which gives the maximum yield-per-recruit (MSY/R = 21.06 at F = 2.4) by about 65.83 %. If the current fishing mortality (0.824) increases to maximum fishing mortality (2.4) the yieldper-recruit will be increased only from 19.92 to 21.69 by about 5.41 %. Also, the estimates of exploitation rate (E = 0.464) showed that Boops boops stock was optimally exploited (GULLAND, 1971). Therefore, keeping the fishing of bogue at the present level of effort will permit harvest of the most of the potential yield (94.59 %) and avoid stock-recruitment problems.

Conclusion

Boops boops is one of many species (mainly sardine and mackerel) targeted by purse seine net, therefore an increase in effort to harvest other species will also affect the bogue, B. boops, stock.

References

- ALLAM, S. M., EZZAT A. A. & MOHAMED, E. E., 1998. Respective of fish landings along Alexandria coast. Bull. Fac. Sci. Alex. Univ., 38 (1): 67–84.
- ANATO, C. B. & KTARI, M. H., 1986. Age et croissance de *Boops boops* (Linné, 1758) poisson téléosteen Sparidae des cotes tunisiennes. Bull. Instit. Nat. Scient. Techn. Oceanogr. Péche Salammbô, 13: 33 – 54.
- BAUCHOT, M.-L. & HUREAU, J.-C., 1986. Sparidae, vol. 2. P. 883–907. In: Fishes of the North-Eastern

Atlantic and the Mediterranean edited by P. J. P. Whitehead, M.-L Bauchot, J.-C Hureau, J. Nilson and E. Tortonese, UNESCO. Paris.

- BEVERTON, R. J. H. & HOLT, S. J., 1957. On the dynamics of exploited fish population. Fish Invest. London, Ser., 2 (19): 533 p.
- BOTROS, G., EL-SHARIF, R. & HUNI, H., 1985. Biometry, length-weight relationship and condition of "*Boops boops*" (L.), family "*Sparidae*" from the western Libyan waters. Bull of M. B. R. C., 6: 78– 101.
- BRAVO DE-LAGUNA, J., 1982. Distribution and abundance of demersal resources of the CINECA region. Rapp. P.-v Réun. Cons. Int. Explor. Mer., 180: 432–446.
- CUSHING, D. H., 1968. Fisheries biology. A study of population dynamic. Univ. Wisconsin press, Madison., 200 p.
- DUTKA-GIANELLI, J. & D. MURIE, D., 2001. Age and growth of sheephead, *Archosargus probatocephalus* (Pisces: *Sparidae*), from the northwest coast of Florida. Bull of Marine Science. 68 (1): 69-83.
- EZZAT, A. A., EL-SAYED, A. M. & AL-DOSSARY, N. A. M., 1992. Growth of fish Lethrinus nebulosus from the Arabian Gulf waters of Dammam (Saudia Arabia). Indian J. of Mar. Sci., 21: 284–286.
- GON, CALVES, J. M. S., BENTERS, L., LINO P. G., BEIRO L. J. R., CANDRIO, A. V. M. & ERZINI, K., 1979. Weight-length relationship for selected fish species of the small-scale demersal fishes of the southwest coast of Portugal. Fish Res., 30: 253 –256.
- GULLAND, J. A., 1964. Manual of methods for fish stock assessment Part I Fish population analysis. FAO, Fish. Techn. Rep. 40 (Revision). 68 p.
- GULLAND, J. A., 1969. Manual methods for fish stock assessment. Fish population analysis. FAO Man fish. Sci., 4: 154 p.
- GULLAND, J. A., 1971. The fish resources of the oceans. Surrey. FAO/Fishing news Books, 255 p.
- HASSAN, M.W.A., 1990. Comparative biological studies between two species of family *Sparidae*, *Boops boops* and *Boops salpa* in Egyptian Mediterranean waters. M.Sc. Thesis, Faculty of Science, Alexandria University, 198 p.
- HERNANDEZ, V. A., 1989. Study on the age and growth of bogue (*boops boops* (L.)) from the central Adriatic Sea. Cybium. 13 (3): 281–288.

- MAIYZA, I. A. & SAID, M. A., 1988. The time variation of temperature, salinity and oxygen content in the Eastern harbour of Alexandria. Bull. Instit. Oceanogr. and Fish. A.R.E., 14 (1): 67–74.
- MERELLA, P., QUETAGLAS, A., ALEMANY, F., & CARBONELLA A., 1997. Length-weight relationship of fishes and cephalopods from the Balearic Islands (western Mediterranean). Naga. ICLARM Q.,20 (3-4): 66–68.
- PAUL, Y, D., 1980. A new methodology for rapidly acquiring basic information on tropical fish stocks; growth, mortality and stock recruitment relationships. P. 154–172. In Stock assessment for tropical small-scale fisheries, edited by S. B Saila

& P. M. Roedel. ICMRD, Univ. Rhode Island, Kinston.

- PAUL, Y. D., 1983. Some simple methods for the assessment of tropical fish stocks. FAO. Fish. Techn. Pap., 234: 52 p.
- PAUL, Y, D. & MUNRO, J. L., 1984. Once more one the comparison of growth in fish and Invertebrates. Fishbyite. 2 (1): 21
- RICKER, W. E. 1975. Computation and interpretation of biological statistics of fish population. Fish. Res. Bd. Canada. 191: 382 p
- STERGIO, K. I. & MOUTOPOULOS. D. K., 2001. A review of length-weight relationships of fishes from Greek marine waters. Naga, ICLARM Q., 24 (1-2): 23 39.