Chapter 20
Stock Assessment of Bogue, *Boops Boops* (Linnaeus, 1758) from the Egyptian Mediterranean Waters

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Abstract The trawl fishery off Egyptian Mediterranean waters consists of 1,400 vessels, yielding a total annual landing of approximately 16,000 t. The bogue (*Boops boops*) is a target species for this fishery, with annual landings oscillating between 1,222 and 3,980 t during the last 18 years. The stock of *Boops boops* in the Egyptian Mediterranean waters has been assessed using a 3 years length frequency data (2007–2009) from the trawl fishery. The vector of natural mortality by age was calculated from Caddy's formula, using the PROBIOM Excel spreadsheet Abella AJ, Caddy JF, Serena F (Aquat Living Resourc 10:257–269, 1997). The method applied was a tuned virtual population analysis (VPA), applying the Extended Survivor Analysis (XSA) method on the period 2007–2009 and Y/R analysis on the pseudo-cohort 2007–2009. The software used was the VIT program. Results showed that the stock is over exploited, being the fishery operating below the optimal yield level since the current Y/R is lower than the maximum. Results suggest a decreasing trend in the average fishing mortality during the study period by about 40 %.

Keywords Age and growth • Population dynamics • Stock assessment • Management

1 Introduction

The Egyptian Mediterranean coast (Fig. 20.1) is about 1,100 km with a mean annual fish production of 55,000 tonnes between 1990 and 2009. The main fishing gears are trawling, purse-seining and lining especially long and hand lining. The fishing grounds along the Egyptian Mediterranean coast are divided into four regions;

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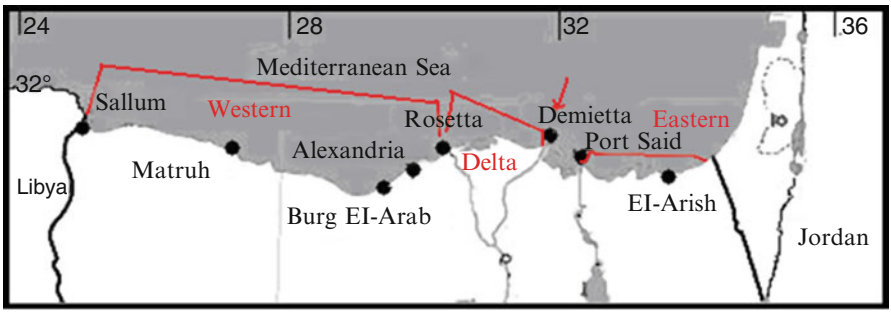

Fig. 20.1 Egyptian Mediterranean coast

Western region (Alexandria and El-Mex, Abu-Qir, Rasheed, El-Maadiya and Mersa Matrouh), Eastern region (Port Said and El-Arish), Demietta region and Nile Delta region (GAFRD 2009). The trawl fishery contributed about 33 % of the total fish production from Egyptian Mediterranean. It is a multi-species fishery targeting a number of commercial important fish species; red mullet, soles, triglid fish, breams, hakes, lizardfish, snappers, elasmobranches and barracuda. Invertebrates are represented by shrimp, cuttlefish, squid, crab and bivalves.

The number of trawlers in the Egyptian Mediterranean ranged between 1,100 and 1,500 during the period from 1990 to 2009. The vessel length varied between 18 and 22 m and its width varied from 4 to 6 m. Each vessel is powered by main engine of 150–600 hp but the majority of 250 hp engines. The fishing trip is about 7–10 days and the number of crew is about 6–15 persons.

Porgies (family: Sparidae) are among the most abundant demersal fishes inhabiting the Egyptian Mediterranean. They represented by more than 10 species and exploited by a variety of fishing gears. *Boops boops* is the most abundant sparid species in the area contributing a mean annual catch of 2,330 t (1991–2009) and exploited by bottom trawlers.

The present work was undertaken in order to provide fishery management advice for the *B. boops* stock in the Egyptian Mediterranean waters. It is aimed at estimating the biological and population parameters required for proposing future plans for sustainable development and management this valuable fish resource.

2 Material and Methods

Monthly random samples of *Boops boops* were collected from Alexandria landing site during the period from June 2007 until April 2009. Each fish was measured to the nearest mm for total length, weighed to the nearest 0.1 g, and its sex and maturity stage were determined macroscopically. Gonads were weighed to the nearest 0.01 g.

Otoliths were removed, rinsed of any adhering tissues, and sorted dry in labeled vials until processing. Annual rings on the otoliths were counted using an optical system consisting of Nikon Zoom – Stereomicroscope focusing block and Heidenhain's electronic bidirectional read out system V R X 182, under transmitted light. The total otolith radius and the radius of each annulus were measured to the nearest 0.001 mm. Regression analyses of otolith maximum radius on total length was calculated by the method of least squares. Back-calculated lengths-at age were computed by using the Lee method (Lagler 1956).

To estimate the relation between length (L) and weight (W), the variables were log transformed to meet the assumptions of normality and homogeneous variance. A linear version of the power function: $W = a*L^b$ was fitted to the data. Confidence intervals (CI) were calculated for the slope to see if it was statistically different from 3.

The growth parameters of the von Bertalanffy (1938) growth model (L_∞ and K) were computed by fitting the Gulland and Holt (1959) plot while the growth performance index was computed according to the formula of Pauly and Munro (1984) as $\phi = \text{Log } K + 2 \text{ Log } L_\infty$: where K and L_∞ are the parameters of von Bertalanffy growth model.

The length at first capture L_c (the length at which 50 % of the fish at that size are vulnerable to capture) was estimated by the method of Pauly (1984) in which the ascending limb of the linearized catch curve is considered to estimate the selection ogive.

The length at first sexual maturity L_{50} (the length at which 50 % of fish reach their sexual maturity) was estimated by fitting the maturation curve between the observed points of mid-class interval and the percentage maturity of fish corresponding to each length interval. Then L_{50} was estimated as the point on X-axis corresponding to 50 % point on Y-axis.

Natural mortality by age was estimated according to the Caddy's formula using the PROBIOM Excel spreadsheet (Abella et al. 1997). Fishing mortalities by age were estimated from VPA. Yield per Recruit analysis (Y/R) was estimated based on the exploitation pattern resulting from the XSA model and population parameters.

The assessment of this stock has been carried out by means of VPA using VIT software (Lleonart and Salat 1997) on a mean pseudo-cohort for the period 2007–2009. VIT model was applied to get an approximate estimate of the fishing mortality, the level of magnitude of recruitment and an indicative estimate $F_{0.1}$.

3 Results and Discussion

3.1 Length-Weight Relationship

Analysis of residual sums of squares indicated no significant difference between the sex-specific length-weight relationships of *B. boops* in the Egyptian Mediterranean

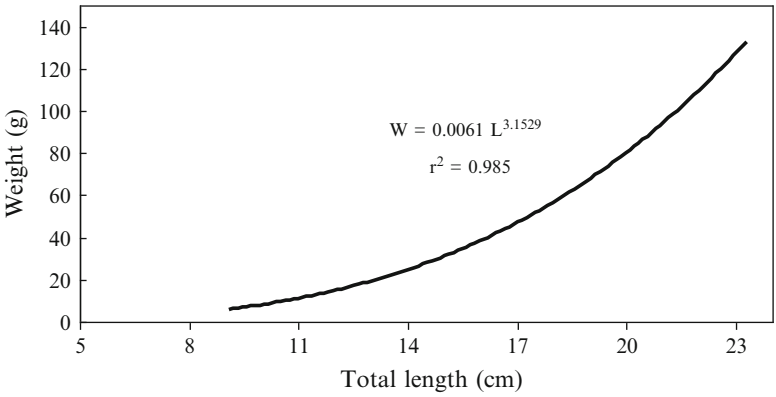

Fig. 20.2 Length-weight relationship of *Boops boops* from Egyptian Mediterranean waters

waters, consequently a power regression was applied to the length-weight data of all individuals combined (Fig. 20.2). The total length varied from 9 to 23.1 cm, while the total weight ranged between 5 and 140 g. The results of the length-weight analyses indicated that this relationship for *B. boops* is highly significant ($p < 0.05$) with high r^2 value (0.985) which indicate increase in length with increase in weight. The slope (b value) of the length weight relationship was 3.1529 which is not significantly different from 3 (95 % CI = 3.0784−3.2273) indicating isometric growth. Also, the value of b (growth exponent) for *B. boops* in the Egyptian Mediterranean waters is within the limits (two and four) reported by Tesch (1971) for most fishes. The obtained value is close to those recorded by Hernandez (1989) who gave b = 3.088 for females and 3 for males in Adriatic Sea, Abdallah (2002) gave b = 3.130 for sexes combined in Alexandria waters, Karakulak et al. (2006) estimated b as 3.258 for sexes combined in Turkey, Kara and Bayhan (2008) gave b = 3.272 for females and 3.522 for males in Turkey.

3.2 Age and Growth

Reliable age determinations are essential for almost all aspects of fishery assessment but especially for studies of growth, production, population structure and dynamics. Accurate estimates of age and growth are required for the management of Bogue fisheries (Mills and Beamish 1980; Girardin and Quignard 1986; Anato and Ktari 1986; Gordo 1996; Panfili et al. 2002; Sana et al. 2005). A total of 900 otoliths of fishes ranging from 9 to 23.1 cm total length were read and used in the estimation of the parameters of the growth models. The results revealed that the maximum life span of *B. boops* was 3 years (Fig. 20.3) and age group one was the most frequent group in the samples and constituted 75 % while the age group three was the least one in the samples (1 %).

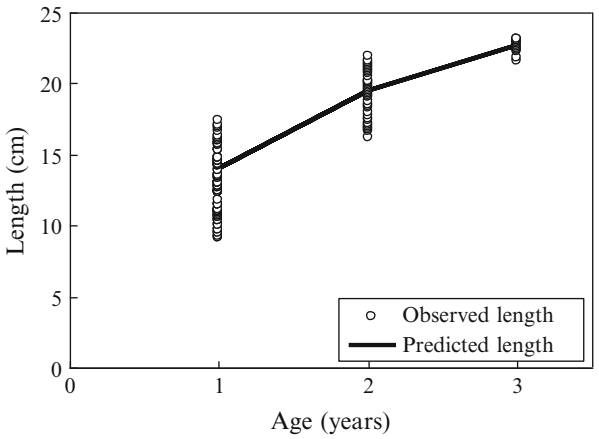

Fig. 20.3 Growth curve of *Boops boops* from Egyptian Mediterranean waters

Table 20.1 Growth parameters (L_∞, K and t_o) and the Phi index of *Boops boops*

Locality	Sex	L_∞	K	t_o	Ø	Author
Adriatic Sea	M + F	33.9	0.17	−1.3	2.28	Hernandez (1989)
Cyprus	M + F	24.0	0.53	−0.45		Livadas (1989)
Algeria	M	26.6	0.21	−2.6	2.17	Djabali et al. (1990)
	F	27.3	0.22	−1.94	2.21	
Egypt	M + F	29.8	0.18	−1.33	2.2	Hassan (1990)
Greece	M + F	36.0	0.40		2.71	Tsangridis and Filippousis (1991)
Morocco	M + F	31.5	0.28	−0.96		Zoubi (2001)
Egypt	M + F	28.1	0.18	−1.13	2.15	El-Haweet et al. (2005)
		29.7	0.25	−0.70	2.34	
Portugal	M + F	28.06	0.22	−1.42		Monteiro et al. (2006)
Egypt	M + F	27.24	0.54	−0.33	2.6	Present study

3.2.1 Growth Parameters

Back-calculated lengths of pooled data were applied according to Gulland and Holt (1959) plot to estimate the von Bertalanffy growth parameters (L_∞, K and t_o). The obtained equations were as follows:

$$\text{For growth in length} \quad L_t = 27.27\left(1 - e^{-0.54(t+0.33)}\right)$$

$$\text{For growth in weight} \quad W_t = 204.36\left(1 - e^{-0.54(t+0.33)}\right)^{3.1529}$$

The growth parameters estimated for *B. boops* in different water bodies were summarized in Table 20.1. The difference in growth parameters between different locations could be attributed to the difference in maximum fish size in the used samples or due to the difference in ecological parameters.

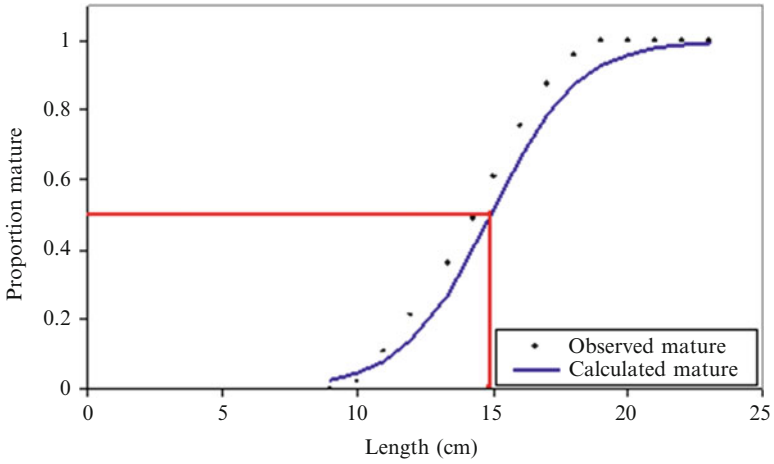

Fig. 20.4 Maturation curve of *Boops boops* from Egyptian Mediterranean waters

3.2.2 Growth Performance Index

Pauly and Munro (1984) have outlined a method to compare the growth performance of various stocks by computing the Phi index ø. The obtained results indicated that the growth performance index (ø) of *B. boops* in the Egyptian Mediterranean waters was 2.6 (Table 20.1).

3.3 Length and Age at First Sexual Maturity

The smallest length recorded in the catch was 9 cm, all fishes of lengths 9–11 cm were immature and those of lengths ≥ 17 cm were mature. The estimated L_{50} was 14.9 cm (1.17 year old) (Fig. 20.4). It was obvious that the length at first capture was smaller than the L_{50}. This means that the exploited *B. boops* must be protected till in order to share at least once in the spawning activity. Therefore, mesh sizes used should be increased to catch fish of about at least 15 cm length. El-Agamy et al. (2004) reported that for *B. boops* in Egyptian Mediterranean all fishes smaller than 12 cm TL were immature while the fishes above 17 cm were mature and the length at first maturity was about 13 cm TL. Monteiro et al. (2006) found that the length at first maturity in Portugal was similar for males and females and the value for both sexes combined was estimated to be 15.22 cm, corresponding to an age range of 1–3 year.

3.4 Length at First Capture L_c

The estimated length at first capture L_c in the present study was 11.3 cm TL (Fig. 20.5). Both the estimated L_c and the observed lengths of fish captured

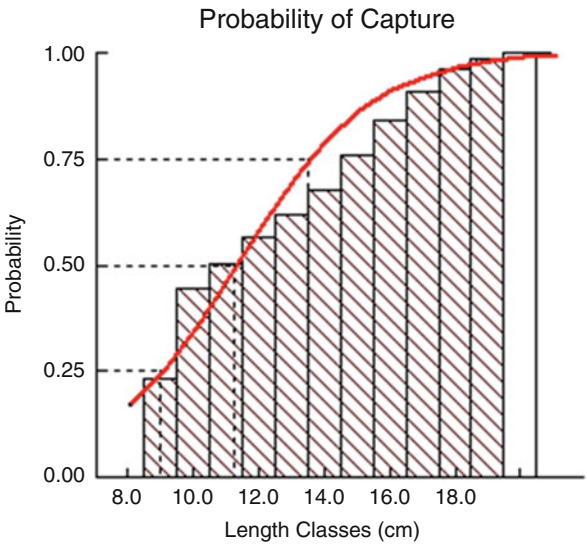

Fig. 20.5 L_c estimation for *Boops boops* from Egyptian Mediterranean waters

indicated growth and recruitment overfishing ($L_{50} = 14.9 > L_c = 11.3$ cm). In the light of these results, a minimum size limit should be implemented for *B. boops* in the Egyptian Mediterranean waters.

3.5 Virtual Population Analysis VPA

The assessment of bogue stock has been carried out by means of VPA (VIT) on a mean pseudo-cohort for the period 2007–2009. A natural mortality at age vector was used within the assessment, based upon the PROBIOM Excel spreadsheet (Abella et al. 1997). The mortality rates for the age groups were 1.67 total mortality, 1.18 fishing mortality and 0.49 natural mortality per year. Also, VIT gave an estimate for total and fishing mortality rates by length groups. The mean total mortality was 1.74 while the mean and global fishing mortality were 1.14 and 0.87, respectively.

Yield per Recruit Y/R analysis shows a clear status of growth overexploitation, due both to a high fishing mortality and an exploitation of the fishery based on juveniles under the minimum legal size. Also, the stock is in danger of recruitment overexploitation due to the decreasing trend in recruitment and very low levels of the spawning stock. Y/R analysis using VIT model (Fig. 20.6) provided the following values of reference points (Table 20.2):

To achieve the $F_{0.1}$ as a reference point, the current F should be reduced by about 38 % if we consider global F as the current F or 53 % if we took the mean F as the current one.

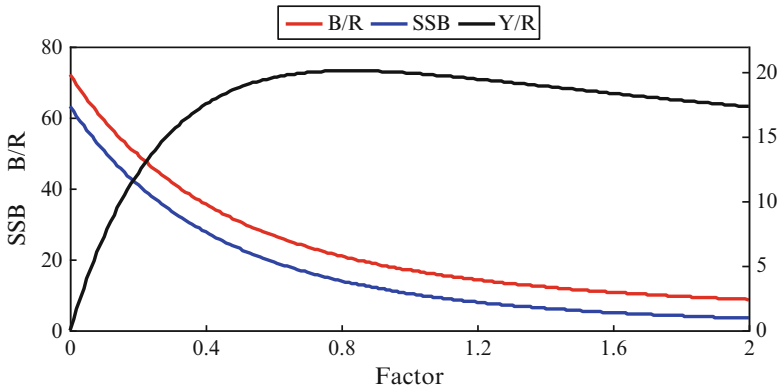

Fig. 20.6 Yield per recruit analysis of *Boops boops* from Egyptian Mediterranean waters

Table 20.2 VIT results

Current Y/R	19.65
Maximum Y/R	20.13
$Y/R_{0.1}$	19.12
F_{max}	0.82
$F_{0.1}$	0.53
Current B/R	14.97
Maximum B/R	72
$B/R_{0.1}$	29.38
$SSB_{0.1}$	21.85
Current SSB	8.59
Maximum SSB	63.1

3.6 Stock Status and Recommendation

The results of the present analysis revealed that the stock of bogue appears overexploited since the current fishing mortality is higher than $F_{0.1}$ and F_{max}. Thus a fishing mortality reduction is necessary in order to avoid future loss in stock productivity and landings.

It is therefore recommended that fishing effort must be controlled and decreased. The available assessment suggests a target reference point of about 30–60 % of the current fishing mortality. Defining nursery areas of important species should be taken into account for recommending closed areas. Also, improving the fisheries data recording system, improving the fishing pattern of the trawl and facilitating data and information exchange are highly recommended.

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