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STOCK ASSESSMENT OF BARRACUDA, GENUS *SPHYRAENA*, ALONG THE EGYPTIAN EDITERRANEAN COAST

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Keywords: stock assessment, yield-per-recruit, fishing mortality, exploitation ratio and Sphyraena species.

ABSTRACT

The size range of the commercial catch of *S. chrysotaenia* (13-27 cm) was less than that of *S. flavicauda* (17-41 cm) and *S. sphyraena* (15-44 cm). The exploitation ratio (E) was relatively high for *S. sphyraena* (0.7893) as well as for *S. chrysotaenia* (0.625) and *S. flavicauda* (0.6026). The length and age at first capture as well as that at recruitment were found to be low for *S. chrysotaenia* (L_c = 17.24cm, t_c = 1.17 yr, & L_r = 16.3cm, t_r = 0.93 yr respectively). The highest values were recorded for *S. sphyraena* (L_c = 25.44 cm, t_c = 1.7664 yr, & L_r = 21.2cm, t_r = 0.69 yr respectively). The present results revealed that at the current level of fishing effort the yield-per-recruit of *S. chrysotaenia* is about 94 % of the maximum sustainable yield. On the other hand, the current yield-per-recruit of *S. flavicauda* is at its maximum sustainable yield while it is slightly higher than the maximum sustainable yield for *S. sphyraena*. Therefore, increasing age at first capture for *S. sphyraena* & *S. flavicauda* will be recommended for regulation of *Sphyraena* fisheries rather than restricting fishing effort.

INTRODUCTION

The barracuda (family *Sphyraenidae*) are mostly pelagic fish although small species belonging to this family live often near the bottom (Whitehead *et al*, 1986). In the Egyptian Mediterranean waters, they are fished on a commercial scale using various fishing gears; namely trawl nets, purse-seines, gill nets, trammel nets and longlines. The barracuda fish constitute about 2.6 % of the total landed catch at the Egyptian Mediterranean coasts. They are locally named "Maghazel, Abu-Maghzal, Zarkan" by native fishermen.

The present study aims to give information on some of the dynamic parameters of barracuda's population as well as, rate of mortality, rate of exploitation and yield-per-recruit.

MATERIALS AND METHODS

Random samples of barracuda fish (*S. chrysotaenia*, *S. flavicauda* and *S. sphyraena*) were collected once a week from the landed catch of the different fishing gears landing in the different fishing centers at Alexandria during the period from March 1998 to February 1999. These fishing gears are gill nets (mesh sizes 5.8 – 8.4 cm), trammel nets (mesh size 2.0 – 2.4 cm for inner layer & 5.6 – 6.8 cm for outer layer), purseseine (mesh size 1.8 cm) and trawlers (cod end with mesh size 2.4 cm). For each specimen, total length (cm) and total weight (g) were recorded and otoliths were taken for age determination. Data on the commercial catch were obtained from the annual statistical reports of the NIOF from the period 1962 to 1990 and GAFRD from 1991 to 2000.

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Total mortality (Z) was obtained according to Ricker (1975). The annual mortality (A) was computed as A = 1 – S, where S is survival rate which was calculated as $S = e^{-Z}$ (Ricker, 1975). Natural mortality (M) was computed from the formula given by Djabali *et al.* (1994) for the Mediterranean teleosts as follows:

$\text{Log } M = -0.0278 - 0.1172 \log L_\infty + 0.5092 \text{ Log } K$

Where L_∞ and K are von-Bertalanffy growth constants. The von Bertalanffy growth constants used in the present study has been determined before when the authors studied age and growth of these species (Allam *et al*, 2004). These constants are: L_∞ = 27.14 cm, W_∞ = 116.78 g, K= 0.3905 & t_o = -1.4145 for *S. chrysotaenia*, L_∞ = 44.58 cm, W_∞ = 443.73 g, K = 0.2955 & t_o = -0.8238 for *S. flavicauda* and L_∞ = 55.27 cm, W_∞ = 604.33 g, K= 0.123 7& t_o = -3.2476 for *S. sphyraena*. Fishing mortality (F) was calculated as F = Z – M (Beverton and Holt, 1957). Exploitation ratio (E = F / Z) was calculated according to Gulland (1971 & 1983). The length at first capture (L_c) was estimated using the formula [$L_c = L^- - K (L_\infty - L^-) / Z$] as given by Beverton & Holt (1957).The corresponding age (t_c) was obtained by converting L_c using the von Bertalanffy growth equation [$t_c = - 1 / K \text{ Ln} (1 - L_c / L_\infty) + t_o$]. The length at recruitment (L_r) was determined from the plot of cumulative percentage curve against the corresponding lengths. The age at recruitment (t_r) was obtained by converting L_r using von Bertalanffy growth constants [$t_r = - 1 / K \text{ Ln} (1 - L_r / L_\infty) + t_o$]. The Yield-per-recruit (Y/R) for weight was determined according to formula developed by Beverton & Holt (1957) as follows:

$Y / R = F. Q. W_\infty [1/Z - (3q /Z+K) + (3q /Z+2K) - (q /Z+3K)]$

Where $Q = \exp. [- M (t_c - t_r)]$ and $q = \exp. [- n K (t_c - t_o)]$ at n = 1,2 & 3 respectively, F is the fishing mortality, M is the natural mortality, Z is the total mortality coefficient, K is the growth coefficient, t_c is the mean age at first capture, t_r is the mean age at recruitment and W_∞ is the asymptotic weight.

RESULTS

Commercial fisheries of barracudas

The mean annual landings of barracuda catch of the Egyptian Mediterranean water during the period from 1962 to 2000 has been subjected to various fluctuations (Fig. 1). The catch of barracuda increased from 47.9 tons in 1962 to 272.3 tons in 1965, then dropped to 18.6 tons in 1967 after that the catch showed some fluctuations till 1977. On the other hand the total landed catch gradually decreased from 37832.2 tons in 1962 till it reached its lowest value in 1975 (5407.2 tons) then increased. After 1977 the barracuda catch increased as well as the total landed catch reaching a maximum value in 1979. Peaks of barracudas catch were observed in 1989, 1991, 1993-1995 and 1997-1998. Generally, the increase of barracudas catch in the last decade was in accordance with a high increase in the total landed catch.

Monthly fluctuations of barracuda's catch during the period from 1965 to 2000 showed a minimum production value during January (16.1 tons) & February (16.2 tons), i.e. in winter and a high value in April (77.8 tons), June (54.8 tons) and July (54.3 tons) i.e. during late spring and summer (Fig. 2).

Size composition

The size compositions of baracuda varied from 13 to 27 cm (mean = 19.92 cm) for *S. chrysotaenia*, from 17 to 41 cm (mean = 26.31 cm) for *S. flavicauda* and from 15 to 44 cm for *S. sphyraena* (mean = 29.46 cm). The majority of individuals of *S. chrysotaenia* (75 31 %) and *S. flavicauda* (75.82 %) ranged from 17 to23 and 19 to 29 cm respectively. while about 58.55% of *S. sphyraena* varied from 29 to 34 cm (Table 1).

Table 1. Size composition of *Sphyraena* species caught during the period from March 1998 to February 1999.

Total length (cm)	***S. chrysotaenia***		***S. flavicauda***		***S. sphyraena***	
	No.	**%**	**No.**	**%**	**No.**	**%**
13	12	0.99	-	-	-	-
14	21	1.73	-	-	-	-
15	49	4.03	-	-	1	0.17
16	80	6.58	-	-	1	0.17
17	122	10.04	7	1.82	2	0.34
18	121	9.96	10	2.60	10	1.69
19	125	10.29	16	4.16	14	2.37
20	149	12.26	19	4.94	16	2.71
21	144	11.85	21	5.45	11	1.86
22	137	11.28	17	4.42	17	2.88
23	117	9.63	25	6.47	27	4.57
24	64	5.27	21	5.45	19	3.21
25	56	4.61	25	6.49	16	2.71
26	16	1.32	33	8.57	18	3.04
27	2	0.16	45	11.69	15	2.54
28			48	12.47	19	3.21
29			22	5.71	35	5.92
30			11	2.86	56	9.48
31			12	3.12	84	14.21
32			7	1.82	81	13.71
33			9	2.34	55	9.31
34			7	1.82	35	5.92
35			6	1.56	22	3.72
36			8	2.08	5	0.84
37			4	1.04	10	1.69
38			6	1.56	6	1.01
39			4	1.04	5	0.85
40			1	0.25	4	0.68
41			1	0.25	3	0.51
42					1	0.17
43					2	0.34
44					1	0.17
Total No.	1215		385		591	
Mean (SD)	19.92 (±2.93)		26.31 (±4.99)		29.46 (±5.07)	

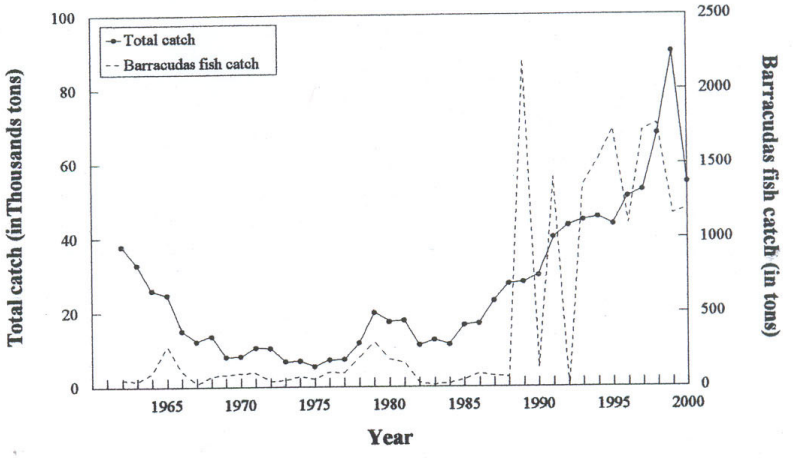

Fig. 1: Annual landing of barracudas fish in comparison to the total landed catch in the Egyptian Mediterranean waters (1962-2000).

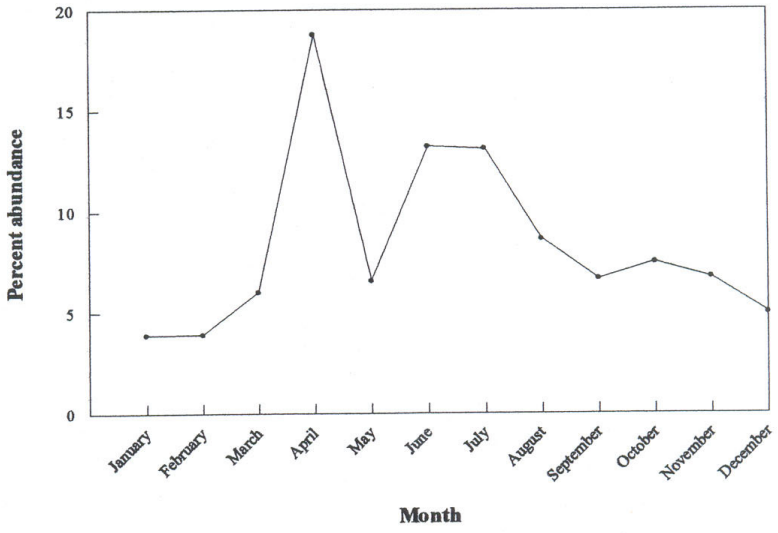

Fig. 2: Mean monthly flactuations of barracudas catch in the Egyptian Mediterranean waters (1965-2000).

Age composition

The age composition of *S. chrysotaenia* varied from 0 to V age groups with an average age of 1.29 year while *S. flavicauda* varied from 0 to VI age groups with an average age of 1.74 year and both species were predominated by age groups I and II (Fig. 3). The age of *S. sphyraena* ranged from 0 to VIII age groups and predominated by age group III (32.66 %) and also by age groups I (18.27 %), II (18.27 %), and IV (13.88 %; Fig. 3).

Mortality and exploitation ratio

Total mortality (Z) was obtained from the catch curve (Fig.4). *Sphyraena chrysotaenia* showed the highest mortality rate (Z=1.0523) followed by *S. flavicauda* (Z=0.8131) and *S. sphyraena* (Z=0.7893; Table 2). The survival rate (S) of *S. chrysotaenia* and *S. flavicauda* was 0.35 and 0.44; i.e. about 35 % of *S. chrysotaenia* and 44 % of *S. flavicauda* survive after age group I. *Sphyraena sphyraena* had a better survival rate (S = 0.45) since about 45 % of them survive after the third year of life (Table 2 & Fig.4). The annual mortality (A) was higher for *S. chrysotaenia* (A = 0.6509) than that for *S. flavicauda* (A=0.5565) and *S. sphyraena* (A=0.5458; Table2). The natural mortality rate (M) of *S. sphyraena* (M = 0.2017) was comparatively lower than those of *S. flavicauda* (M = 0.3231) and *S. chrysotaenia* (M = 0.3946). The fishing mortality (F) of *S. chrysotaenia* (F = 0.6577) was higher than that of *S. flavicauda* (F = 0.4900) *S. sphyraena* (F = 0.5876; Table 2). The exploitation ratio (E) was relatively high for *S. sphyraena* (0.7876). This ratio was also found to be high for *S. chrysotaenia* (0.6250) and *S. flavicauda* (0.6026; Table2).

Length and age at first capture and at recruitment

The length (L_c) and age (t_c) at first capture were low for *S. chrysotaenia* (L_c = 17.24 cm & t_c = 1.17 yr) while the highest values were observed for *S. sphyraena* (L_c = 25.44 cm & t_c = 1.77 yr; Table 4). As shown from Fig5, the small length at recruit (L_r) was recorded for *S. chrysotaenia* (L_r= 16.3 cm) corresponding to t_r = 0.94 yr and the high value was recorded for *S. sphyraena* (L_r = 21.20 cm) corresponding to t_r = 0.69 yr (Table3).

Yield-per-recruit

The yield-per-recruit (Y/R) for different fishing mortalities of *S. chrysotaenia*, *S. flavicauda* and *S. sphyraena* caught by different gears were graphically represented in Fig. 6. As shown from these figures, the estimated yield-per-recruit (Y/R) increases continuously with the increase of fishing mortality reaching its climax at maximum sustainable yield (MSY) then it remained more or less constant.

For *S. chrysotaenia*, the maximum sustainable yield (MSY = 29.19 g) was attained at fishing mortality of F = 1.8 while at the level of fishing operation (F = 0.6577, t_c = 1.1681 year and L_r= 16.3 cm the Yield-per-recruit was 27.46 g. The Yield-per-recruit at the present fishing mortality was less than the maximum sustainable yield by about 5.93 %. So, Increasing the Yield-per-recruit at the present fishing mortality to the maximum economic yield (EY) will increase the fishing mortalities by 52 % and the Yield-per-recruit will increase only by about 4 % (Fig. 6a).

For *S. flavicauda*, at the present fishing mortality (F = 0.49), t_c = 1.1458 year and L_r =19.20 cm the yield-per-recruit (Y/R = 60.07 g) was nearly the same as the maximum sustainable yield (MSY= 60.08 g at F = 0.5). Therefore, when t_c of *S. flavicauda* was increased to 2 (25.23 cm) and 2.5 years (27.89 cm) the yield-per-recruit will be increased by 5.76 and.10.25 % and % respectively (Fig. 6b).

For *S. sphyraena*, the current yield-per-recruit (Y/R = 57.77 g at F=0.5876, t_c = 1.5646 year & L_r = 21.20 cm) was slightly exceeded than that associated with the maximum sustainable yield (MSY=58.45g at F=0.4; Fig. 6c). Therefore, when t_c increased to 2.0 (26.29 cm), 2.5 (28.01 cm) and 3.0 years (29.64 cm) the current yield-per-recruit will be increased by about 1.20, 5.14 and 7.55 %.

Table2. Fisheries parameters used for assessing the stock for *Sphyraena* species.

Parameters	*S. chrysotaenia*	*S. flavicauda*	*S. sphyraena*
Total mortality (Z)	1.0523	0.8131	0.7893
Survival rate (S)	0.3491	0.4435	0.4542
Annual mortality (A)	0.6509	0.5565	0.5458
Natural mortality (M)	0.3946	0.3231	0.2017
Fishing mortality (F)	0.6577	0.4900	0.5876
Exploitation ratio (E)	0.6250	0.6026	0.7876

Table3. Length and age at first capture (L_c &t_c) and at recruit (L_r & t_r) for *Sphyraena* species.

Parameters	*S. crysotaenia*	*S. flavicauda*	*S. sphyraena*
Length at first capture ($\mathbf{L_c}$)	17.2707	19.67	25.44
Age at first capture ($\mathbf{t_c}$)	1.1681	1.1458	1.7664
Length at recruitment ($\mathbf{L_r}$)	16.30	19.20	21.20
Age at recruitment ($\mathbf{t_r}$)	0.9358	0.8238	0.6858

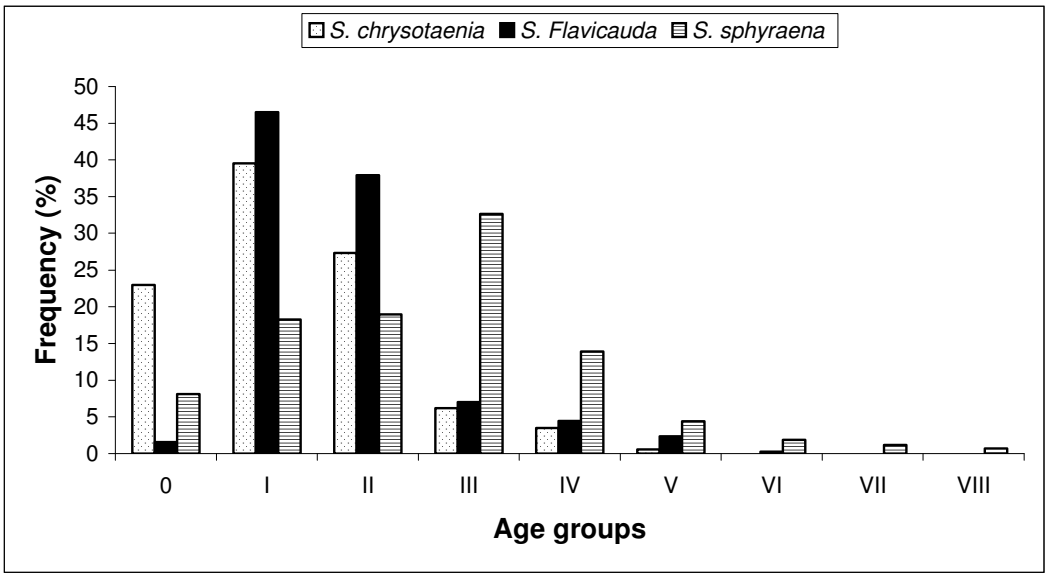

Fig.3. Percentage of age composition of *Sphyraena chrysotaenia*, *S. favicauda* and *S. sphyraena*.(Total number= 1215 & mean age=1.29 ±1.03 for *S. chrysotaenia*, total number=385&mean age=1.74±0.98 for *S. favicauda* and total number=591 & mean age=2.56 ±1.52 for *S. sphyraena)*

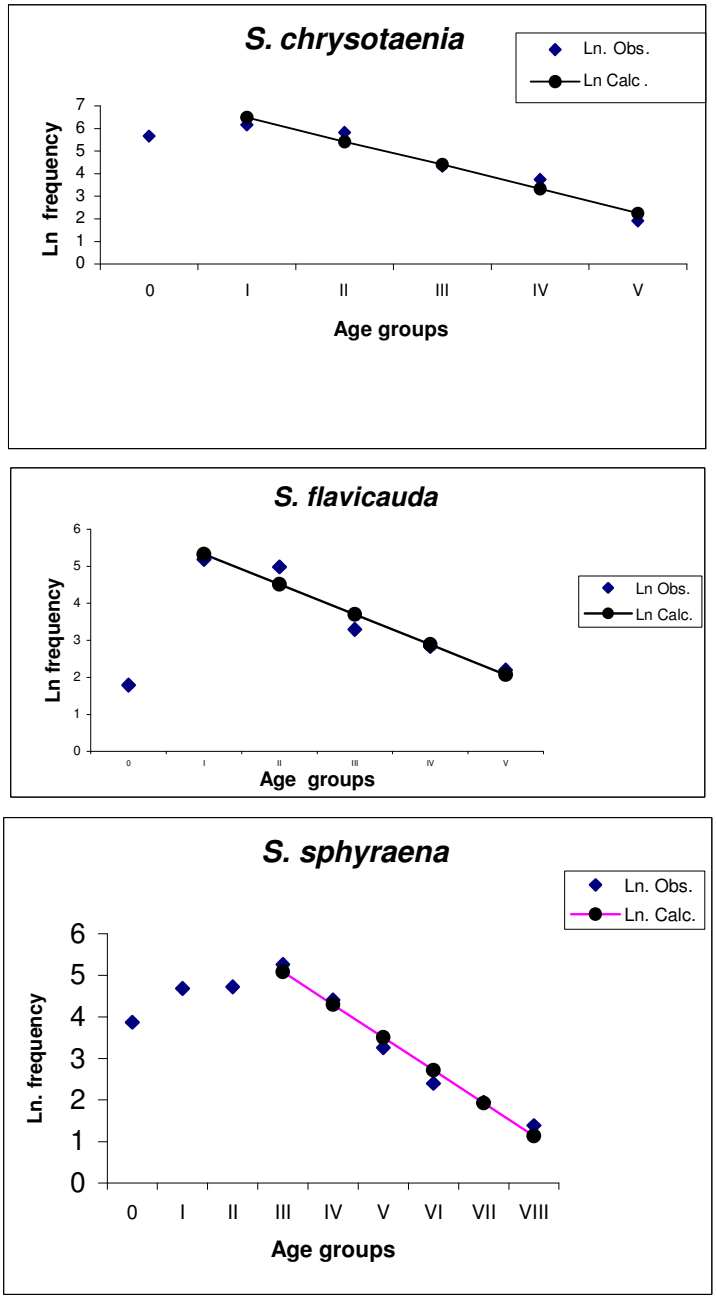

Fig. 4. Catch curve of *Sphyraena chrysotaenia*, *S. favicauda* and *S. sphyraena*.

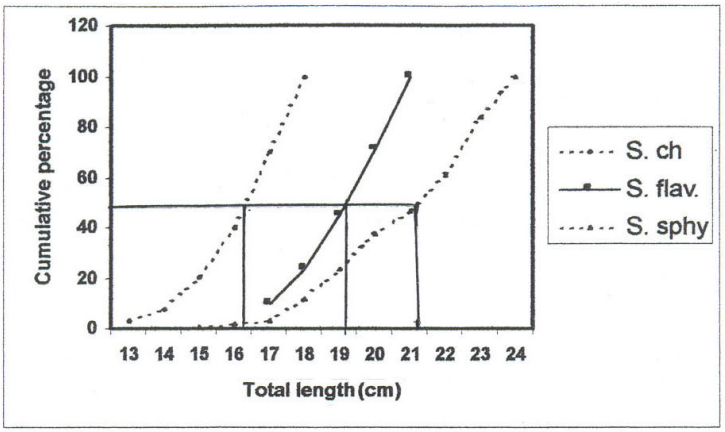

Fig. 5. Cumulative curves of recruit percentages at different length groups for *Sphyraena chrysotaenia*, *S. favicauda* and *S. sphyraena*.

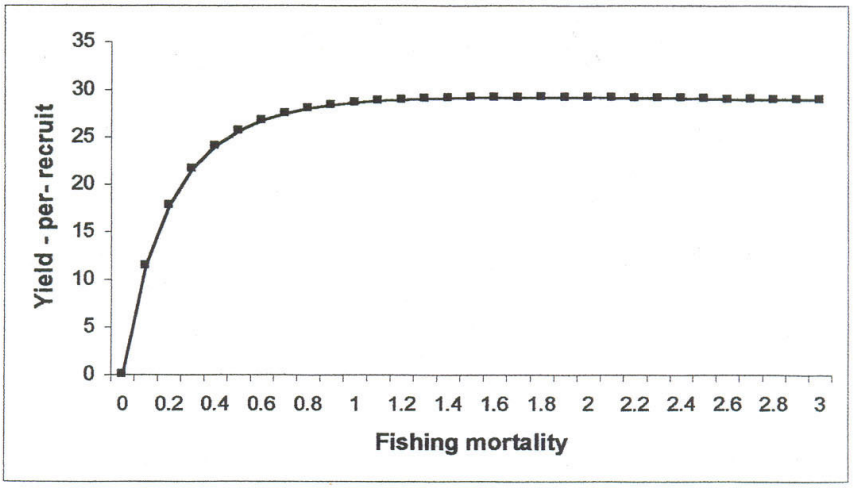

Fig. 6a. Yield-per-recruit for different fishing mortalities and different ages at first capture (t_c) for *Sphyraena chrysotaenia*.

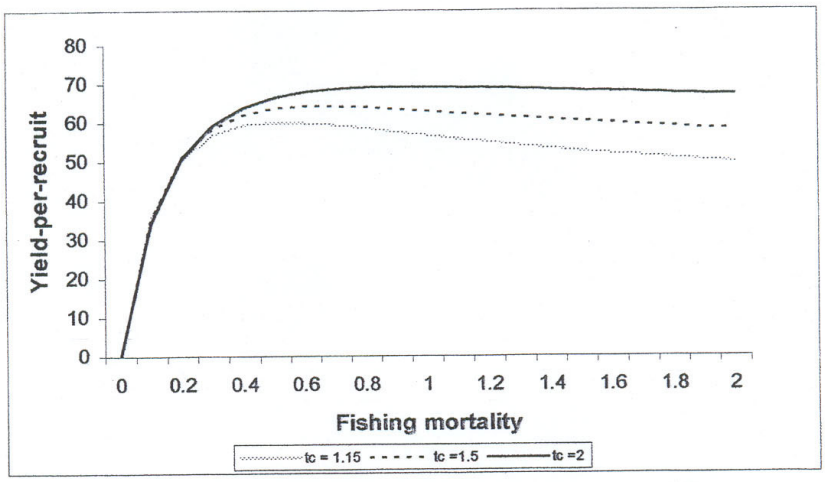

Fig. 6b. Yield-per-recruit for different fishing mortalities and different ages at first capture (t_c) for *S. favicauda*

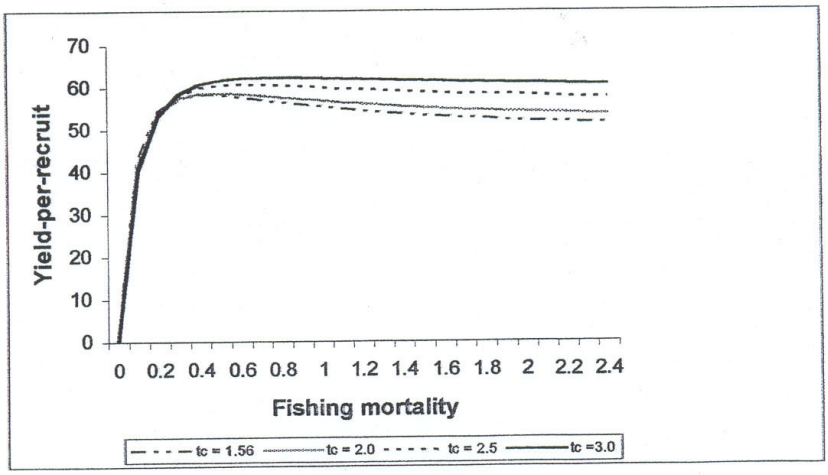

Fig. 6c. Yield-per-recruit for different fishing mortalities and different ages at first capture (t_c) for *S. sphyraena*

DISCUSSION

The size range of *S. chrysotaenia* (13-27) was less than that recorded for *S. flavicauda* (17-41) and *S. sphyraena* (15-44). The size ranges of *S. chrysotaenia* in the present study are concomitant with those in the Mediterranean coast of Israel (Ben-Tauvia, 1971), Egypt (Wadie *et. al*, 1987), Greece (Corsini & Economidis, 1999) and Turkey (Taskavak & Bilecenoglu, 2001). The size range of *S. sphyraena* in the present study is in accordance with those recorded in the Mediterranean coast of Lebanon (George *et al*, 1971), Egypt (Wadie *et al*, 1987) and Italy (Relini &Orsirelini, 1997).

The present results on age composition for *S sphyraena* (from zero to VIII) were in disagreement with Rizkalla (1985; from zero to III) while it was in agreement with his results concerning *S. chrysotaenia* (from zero to V). The domination of zero groups for *S. chrysotaenia* indicates that the spawning grounds are probably their fishing grounds (Allam *et al*, 1998).

The length at first capture for all *Sphyraena* species were less than the lengths at first sexual maturity (17.3 cm for ♂& 19.3 cm for ♀ of *S. chrysotaenia*, 25.5 cm for ♂ & 28.0 cm for♀ of *S. flavicauda* and 26.7 cm for ♂& 27.6 cm for ♀ of *S. sphyraena*; Allam *et al*, 2004).

Sphyraena sphyraena was found to have a higher rate of survival than the other two species, since about 45 % of individuals survive after age group III for that species. The natural mortality rate was low for *S. sphyraena* (0.2017) and *S. chrysotaenia* (0.3231) and high for *S. flavicauda* (M =0.3946), i.e. *S. flavicauda* seem to suffer from natural mortality than the other two species. This may indicate that environmental conditions satisfy the requirements for successful propagation and immigration for *S. chrysotaenia* which is a Lessepsian migrant.

For a stable fishery, Gulland (1971) suggested that the exploitation ratio should not be more than 0.5 as optimum exploitation where $F_{opt.} = M$. According to the present study, F > M for all *Sphyraena* species which indicates to a high exploitation rate for the three species.

Estimation of the yield-per-recruit according to Beverton and Holt (1957) for the three species under study revealed that at the current level of fishing effort the yield-per-recruit of *S. chrysotaenia* is about 94 % of maximum sustainable yield while the yield-per-recruit of *S. sphyraena* and *S. flavicauda*, is equal to their maximum sustainable yield. According to Fig. 6b &c, it can see that increasing age at first capture for *S. sphyraena* & *S. flavicauda* will lead to increase in the yield-per-recruit. Allam (2003) found that by keeping the fishing effort of bogue (*Boops boops*) from waters off Alexandria at the present level of effort will permit harvest 94.59 % of the maximum sustainable yield. On the other hand, Gulland (1978) stated that the size regulation is usually preferable since it does not have drastic effects on the individual fisherman as restricting fishing effort.

The stock of *Sphyraena* species in the Egyptian Mediterranean waters are fully exploited as given by yield-per-recruit estimations. So, increasing age at first capture by developing different fishing gears is to be recommended for regulation of *Sphyraena* fisheries rather than restricting fishing effort which have a drastic effect on the fishermen. In fact *Sphyraena* species appear among other species in the catch obtained by trawl nets, gill nets, trammel nets and purse-seines, hence similar studies must be done to other economically important species which might be fished with the same gears used for *Sphyraena*. This means that good monitoring of fishing effort is essential.

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