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FISHERY STATUS OF THE STRIPED MULLET (PISCES: MUGILIDAE) FROM BARDAWIL LAGOON, EGYPT
I- AGE AND GROWTH OF *MUGIL CEPHALUS*

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Key words: *Mugil cephalus*, age and growth, length frequency analysis, Bardawil lagoon.

ABSTRACT

This study deals with age determination of the striped mullet *Mugil cephalus* collected from Bardawil Lagoon during four successive fishing seasons (1995 to 1998). The scale reading and length frequency analysis show that the catch of *M. cephalus* consists of 6 year classes. Age groups I and II represent the bulk of the catch. The growth parameters were determined from both length frequency and length-at-age data. The estimated parameters based on length –at-age data were L_∞ = 74.164 cm., K= 0.246 Y^{-1} and t_0 = -0.969 The similarity of the estimated growth parameters is reflected in the small range of the growth performance index (φ), which indicates the compatibility of the two methods for the assessment of this species. The length weight relationship was calculated for each season separately and the mean resultant formula was $W= 0.01547\ L^{2.8558}$.

INTRODUCTION

Mullets are one of the most valuable resources in Bardawil lagoon, they constitute more than 40% of the lagoon production. The catch statistics show that the striped mullet production in Bardawil lagoon is variable, it is fluctuated between 140 tons and 523 tons during the last ten years. Mullets are fished in Bardawil lagoon with

two fishing gears namely veranda (Bouss) and Dabba which depends on trammel nets.

The species composition of the mullets in the lagoon catch is composed of *Mugil cephalus, Liza ramada, Liza aurata, Liza saliens* and *Chelon labrosus* of which *Mugil cephalus* is the most abundant species contributing more than 50% of the mullet species.

Most of the fisheries studies on the lagoon concerned its management using MSY (Pisanty, 1981; Bebars *et al*, 1992 and Breikaa, 1997) . A little attention was given to the species population dynamics (Ben Tuvia, 1979 and Bebars, 1986). This contribution is the first in a series to study the population dynamics of the striped mullet in Bardawil lagoon for the proper assessment and management of this valuable resource.

MATERIALS AND METHODS

Study area:

Bardawil lagoon (Fig. 1) lies between 31° 03¯ & 31° 14¯N and E 32° 40¯ & 33° 30¯E in the northern part of Sinai Peninsula, Egypt. The lagoon is separated from the Mediterranean Sea by a sandy bar with two narrow inlets. It is considered as a natural depression with a depth of 1-3 m. The bottom of the lagoon is sandy along its shores, silt-muddy in the deepest part. The rest of the area is composed of muddy-sandy substrate. Most of the bottom is covered by the sea grass *Ruppia sp.* The salinity is 45 to 55 ppt and the water temperature ranges from 12.7°C in January to 30.5°C in June (Pisanty, 1981). The fishing is seasonal, starts from the beginning of May to the end of December.

Collection of data:

Monthly samples of *Mugil cephalus* were collected from the commercial catch of the two landing sites in Bardawil lagoon, from the fishing season 1995 to 1998. The data were based on fish samples caught by the different gears (Veranda and Dabba) operating in the Lagoon.

Each sampled fish were measured from the tip of the snout to the end of the caudal fin (total length) to the nearest cm and weighed to the nearest gram for the whole period of sampling. For the samples of the 1995 fishing season, scales were collected from representative sub-samples and preserved in special envelops for the purpose of age determination.

Length-at-age data:

Length-at-age data were based on the scale reading of about 585 specimens. The scales were cleaned, dried and bounded tightly between two glass slides, then examined using a Nikon zoom stereo-microscope. The total scale radius and each annulus radius were measured to the nearest 0.001 mm. The fish length-scale radius relationship was determined and the constants of the relationship were calculated by the least square regression method. Length-at-age were back-calculated according to Lee's (1920) equation.

Length frequency analysis:

The collected monthly length frequency samples were grouped into 2 cm classes, and analyzed by adopting Bhattacharya (1967) method incorporated in the FiSAT routin of programs (Gayanilo *et al.*, 1995). For the final decomposition of the composite distribution into normal distributions, the samples were pooled as seasonal ones for the separation of annual age groups or cohorts.

Growth estimates:

A preliminary estimate of the von Bertalanffy growth parameter (L_∞) was based on the method of Wetherall (1986) as modified by Pauly (1986), where the monthly length frequency data were raised to the monthly total catch for the four analyzed fishing seasons. The weight of the samples was estimated using the length weight relationship derived from samples of 3999, 8461, 3261 and 2568 specimens for the successive fishing seasons respectively. A full complement of growth parameters (L_∞ K and t_0) was obtained using the mean back-calculated length-at-age and the mean assigned lengths at age derived from Bhattacharya method, as treated by the least squares method (Gayanilo *et al.*, 1995).

RESULTS AND DISCUSSION

Length weight relationship:

The length weight relationship is required in population dynamics and fisheries stock assessment, since the rate of increase in weight reflects how the ecological factors of a habitat affect the fish in which it lives, particularly the amount of food available (Le Cren, 1951). The mathematical relationship between length and weight in

most fish can be described by a formula of the type $W = a L^b$ where W is the fish weight, L is the fish length and a and b are constants.

For the analysis of length weight relationship of *Mugil cephalus*, the least square method was applied for the samples of each season separately and the results of the correlation coefficient and the constants (a and b) are given in Table (1). The analysis showed that the mean length in the catch is gradually decreased from 31.94 cm in the fishing season 1995 to 30.92 cm in 1996 and 30.40 cm. during 1997 then declined to be 28.13 cm during 1998.

Bebars (1986) estimated the length weight relationship for *M. cephalus* in Bardawil lagoon as $W = 0.0182\ L^{2.8174}$ which is comparable to the results obtained in the present study.

Age determination:

The scales of *M. cephalus* proved to be the most reliable hard structure for age reading, since the increase in size of fish is accompanied by an increase in the number of annuli and the high degree of correlation ($r = 0.93332$) between size of fish and the scale radius denotes that as the fish grows, the scale increase in size.

The relation between the total fish length and the anterior scale radius was determined for 585 specimens ranging in total length from 14.0 to 64.0 cm. The resultant relationship is linear and can be represented as:

$$L = 6.2381 + 2.2133\ S$$

Where L is the total fish length in cm and S is the scale radius in mm with the correlation coefficient of 0.93332.

The fish length corresponding to each scale annulus was calculated according to Lee's (1920) equation and the back-calculated lengths at the end of the different years of life are given in Table (2). Thus it was clear that the maximum increment is observed at the first year of life, whereas in the following years the rate of growth slows down. During the first three years of life, the striped mullet reached a length of 46.45 cm and in the following three years the total length increased by only 12 cm.

Bebars (1986) estimated the longevity of the *M. cephalus* from Bardawil lagoon as five years old for females and three years old for males. The back-calculated lengths recorded by him were 29.01, 43.03, 54.32, 61.59 and 66.27cm for females and 27.36, 36.84 and 42.99cm for males respectively. The lengths of the first year of life were the only ones comparable with the present work.

Length frequency analysis:

The monthly length frequency distributions are represented in Figures (2 & 3) for the four successive fishing seasons from May 1995 to November 1998. The sampling during the fishing season 1997 was restricted in four months. It was clear that the frequencies of the small lengths < 16.0 cm appear in June and July which indicated that recruitment to the fishery occurs through these months.

The seasonal distributions were analyzed by Bhattacharya (1967) method, which provided a maximum of 6 age groups for the samples of the three fishing seasons 1995 to 1997 and 5 age groups for the samples of 1998 (Fig. 4). The identified age groups were assigned to mean lengths of the component distributions in each length composition sample. The assigned lengths at age for each group with their predicted lengths and the statistical residual are given in Table (3). It shows the good agreement between the mean lengths at age for the samples of 1995 and 1996 and the corresponding back-calculated lengths based on scale reading. While the assigned lengths at 1997 and 1998 tend to be smaller, which may be due to the increase of the frequencies of the small-size classes and the disappearance of age group 6 in the fishing season 1998. This could be an indication of growth and recruitment over-fishing.

Age composition:

The age composition of the striped mullet *Mugil cephalus* was studied regardless of sex and the maximum age was found to be 6 years old. The percentage of the different age groups was 10.77, 38.97, 34.36, 12.14, 2.39, 0.85 and 0.51 percent for age groups 0, I, II, III, IV, V and VI respectively. Figure (5) shows that age groups I and II are the dominant groups in the catch. Therefore, it is reasonable to assume that individuals of *Mugil cephalus* are fully recruited to the fishery in Bardawil lagoon at an age of one year. The results of Babers (1986) also indicated that the bulk of the striped mullet catch in the lagoon consists of age group one.

Growth estimates:

The von Bertalanffy (1938) growth parameters (L_∞, K and t_0) of *M. cephalus* were estimated by two different methods. The least squares method (Gayanilo *et al.*, 1995) was applied for the length-at – age data, as well as for the assigned mean lengths derived from Bhattacharya (1967) method. The Wetherall (1986) method for the

estimation of L_∞ and Z/K was adopted for the raised length composition of the seasonal samples, the estimated parameters are given in Table (4) and the theoretical growth curve for the four successive fishing seasons are illustrated in Figure (6). The results show that the L_∞ estimates are in gradual decrease recording its minimum value in the fishing season 1998, this can be regarded to the small maximum recorded length (52.2 cm) during that season.

Comparison of the results of the present work with that preceded in literature is summarized in Table (5). The estimate of the growth parameters by different authors in various localities, revealed that, there is no definite growth pattern for the parameters estimated by different authors and the results diverge between different authors in different areas. These differences might be explained by the different methods applied for age determination (Oren, 1981); also these differences could be explained by the worldwide distribution of this species, and its different survival strategies (Ibanez Aguirre, 1999). However, the results of the present study are comparable to those obtained by Erman (1959) in Turkey (Mediterranean Sea), Thompson (1963) in Australia and Bebars (1986) in Bardawil lagoon.

Conclusion

The back-calculated lengths of *Mugil cephalus* based on the scale reading and the assigned lengths at age derived from length frequency analysis were found to be comparable, The growth parameters obtained from length at age data were very similar to those obtained from length frequency data, indicating compatibility of the two data sets and methods applied. This was confirmed by the values of the growth performance index ($\Phi = \mathbf{Log10\ K + Log10\ L_\infty}$) developed by Pauly and Munro (1984) and given in Table (4). The value of this index as stated by Pauly and Munro is comparable inspite of the presence of differences between different populations.

Therefore, the length frequency data are cosidered sufficient, for this relatively shot-lived species to obtain reliable growth parameter estimates, and that further population dynamic studies should be undertaken to assess the striped mullet resource in Bardawil lagoon.

REFERENCES

Annala, J. H. (comp.) (1994). Report from the fishery assessment planar, May 1994: stock assessment and yield estimates. Unpublished report held in MAF Fisheries Greta Point library, Wellington. *242p.*

Bebars, M. I. (1986). Second scientific report on the stock assessment management of the Bardawil lake fisheries submitted to the Academy of Scientific Research and Technol., *December* 1986.

Bebars, M. I.; Ahmed, O. K. and Briekaa, M. I. (1992). Fisheries management of Bardawil lagoon (North Sinai, Egypt). Project of fish resources development in Bardawil lagoon. Final report. Academy of Scientific Research and Technol., *93p.*

Ben-Tuvia, A. (1979). Studies of the population and Fisheries of *Sparus aurata* in the Bardawil lagoon. eastern of Mediterranean. Invest. Pesq. Barc., *43*(1): 43-67.

Betralanffy von, L. (1938). A quantitative theory of organic growth. Hum. Biol., *10* (2) : 181-213.

Bhattacharya, C. G., (1967). A simple method of resolution of a distribution into gaussian components. *Biometrics, 23*(1): 115-135.

Breikaa, M. I. M. (1997). Fisheries management studies on the Bardawil lagoon, Northern Sinai, Egypt. Egypt. J. Aquat. Biol. & Fish., *1(2)*: 291-307.

Cech, J. J. Jr. and Wohlschlag, D. E. (1975). Summer growth depression in the striped mullet, *Mugil cephalus.* Contrib. Mar. Sci., *19*: 92-100.

Diaz P. E. and Hernandez, S. (1980). Crecimiento, reproduccion y habitos alimenticios de la lisa *Mugil cephalus* en la Laguna

de San Andres, Tamps. An. Esc. Nal. Cienc. Biol., Mexico, *23*:109-127.

Erman, F. (1959). Observation on the biology of the common grey mullet (*Mugil cephalus*). Proc. Tech. Pap. Gen. Fish. Counc. Mediterr., *5*: 157 - 169.

Farrugio, H. (1975). Les muges (Poissons, Teleosteens) de Tunisie: repartition et peche. Contribution a leur etude system-antique et biologique. M.S. thesis, Universite des Sciences et Techniques du Languedoc. Montpellier, 316pp.

Gayanilo, F. C. Jr. ; Sparre, P. and Pauly, D. (1995). The FiSAT user's guide. FAO computerized information series fisheries, 99, ICLARM, DIFMAR, Rome.

Ibanez- Aguirre, A. L.; Gallardo-Cabello M. and Carrara, X. C. (1999). Growth analysis of striped mullet, *Mugil cephalus*, and white mullet, *M. cureme* (Pisces : Mugilidae), in the Gulf of Mexico. Fish. Bull., *97*: 861-872

Ih-Hsiu Tung, (1970). Studies on the fishery biology of the grey mullet *Mugil cephalus*, in Taiwan. P. 491-504. In J. C. Fast West Center Press. Honolulo.

Jingran, J. K. and Misra, I. L. (1962). Further-tagging experiments in Chilka-Lake, with special reference to *Mugil cephalus* Linnaeus. Indian J. Fish., *9(2)*: 129-197.

Le Cren, D. E. (1951). The length weight relationship and seasonal cycle in gonad weight and condition in the perch Perca fluviatilis. J. Anim. Ecol., *20*(2): 201-219.

Lee, R. M. (1920). A review of the methods of age and growth determination in fishes by means of scales. Fish. Invest. Min. Agr. Fish. Ser., *2 :4*(2) :1-23.

Marquez, M. R. (1974). Observaciones sobre mortalidad total y cercimiento en longitud de la lisa (*Mugil cephalus)* en la laguna da Tamiahua, ver., Mexico. I.N.P. de Secretaria de Pesca, 15pp.

Morovic, D. (1964). Contribution a la connaisance de la croissance annuelle de *Mugil cephalus L.* et *Mugil chelo* Cuv. Dans l'Adriatique. Acta adriatica, *11*:195-204.

Oren, O. H. (1981). "Aquaculture of grey mullets." Cambridge Univ. Press. Cambridge, U. K., 507pp.

Pauly, D. (1979). Theory and management of tropical multispecies stocks : a review with emphasis on the southeast Asian demersal fisheries. ICLARM stud. Rev.,*1:* 35p.

Pauly, D. (1986). On improving operation and use of the ELEFAN programs, part III. Correcting length frequency data for the effects of gear selection and/ or incomplete recruitment. Fishbyte, *4* (1):18-20.

Pauly, D. and Munro, J. L. (1984). Once more on the comparison of growth in fish and invertebrates. Fishbyte, *2*(1): 21.

Pisanty, S. (1981). The fishery and management of the hypersaline lagoon of Bardawil. Stud. Rev. Gen. Fish. Counc. Mediterr., *58*: 35-73.

Thompson, J. M. (1963). Synopsis of biological data on the grey mullet *Mugil cephalus* L. 1758. Fish. Synop. Div. Fish. Oceanogr. CSIRO, Aust., *1*:1-75.

Wetherall, J. A. (1986). A new method for estimating growth and mortality parameters for length frequency data. Fishbyte., *4* (1): 12-14.

Wijeyaratue, M. J. S. and Costa, H. H. (1987). Fishery seasonal abundance and mortality of grey mullets (Pisces: Mugilidae) in Negombo Lagoon, Sri Lanka. J. Appl. Icthyol.,*3*: 115-118.

Table (1) Constants of length weight relationship for *Mugil cephalus* from Bardawil Lagoon collected from 1995 to 1998.

Constant	1995	1996	1997	1998
a	0.01597	0.01450	0.01567	0.01547
b	2.86883	2.86794	2.84480	2.85580
r^2	0.90779	0.96168	0.93639	0.95480
n	3999	8461	3261	2568

Table (2) Mean observed, back-calculated lengths at the different years of life for *Mugil cephalus* from Bardawil lagoon.

Age	No	Range of observed length	Mean observed length (± SD)	Back-calculated length (± SD)
0	63	14.9-25.8	20.50 (± 3.33)	17.5 (± 4.32)
I	228	23.6-35.9	30.61(± 4.24)	28.56 (±3.45)
II	201	34.6-46.6	40.41(± 2.97)	38.19 (± 2.27)
III	71	44.3-54.8	49.75 (± 2.76)	46.45 (±2.23)
V	14	51.8-57.5	54.78 (± 2.28)	52.01(± 2.10)
IV	5	54.0-62.3	60.67 (± 2.25)	57.54 (± 0.64)
VI	3	60.2-64.0	62.90 (± 0.68)	60.57 (± 0.66)

Table (3) Back calculated lengths,assigned lengths at age obtained from Bhattasharya method and the corresponding pridected lengths and their residual for *Mugil cephalus* from Bardawil lagoon.

Year	Method	Years of life						
		0	1	2	3	4	5	6
1995	Back-calculated	17.50	28.56	38.19	46.45	52.01	57.54	60.57
	Pridected	17.15	28.47	38.43	46.22	52.32	57.08	60.80
	Residual	0.26	0.09	-0.24	0.23	-0.31	0.46	-0.23
1995	Assigned	18.22	29.22	37.89	46.70	52.46	55.00	61.03
	Pridected	17.68	29.11	38.50	45.96	51.87	56.57	60.29
	Residual	-0.28	0.12	-0.61	0.74	0.59	-1.57	0.74
1996	Assigned		26.52	38.15	46.21	53.13	59.21	61.40
	Pridected		26.46	37.99	46.69	53.26	58.22	61.97
	Residual		0.03	0.16	-0.47	-0.13	0.20	-0.57
1997	Assigned		26.66	35.93	45.56	51.41	56.12	59.00
	Pridected		26.27	36.95	45.05	51.19	55.84	59.37
	Residual		0.39	-1.02	0.51	0.22	0.28	-0.37
1998	Assigned	13.00	24.03	32.42	41.00	47.33	50.00	
	Pridected	12.62	23.66	33.37	40.75	46.36	50.63	
	Residual	0.62	0.36	-0.95	0.25	0.97	-0.63	

Table (4) Estimates of the von Bertalanffy growth parameters for *Mugil cephalus* according to the different methods used.(standerd error are given in brackets)

Year	Method	L_∞	K	t_0	Φ	r^2
1979	Least squares method for back-calculated lengths	74.164 (2.283)	0.246 (0.021)	-0.969 (0.119)	3.131 (0.525)	0.9984
1979	Least squares for lengths from Bhattacharya method	74.613 (7.676)	0.231 (0.066)	-1.138 (0.406)	3.11 (0.647)	0.9845
	Wetherall	72.792	0.229	-0.575	3.084	0.9640
1979	Least squares for lengths from Bhattacharya method	73.591 (3.249)	0.28 (0.036)	-0.595 (0.156)	3.181 (0.613)	0.9956
1996	Wetherall	71.536	0.266	-0.495	3.134	0.9680
1979	Least squares for lengths from Bhattacharya method	70.439 (3.463)	0.277 (0.040)	-0.686 (0.183)	3.138 (0.549)	0.9945
1997	Wetherall	66.073	0.288	-0.466	3.099	0.9630
1979	Least squares for lengths from Bhattacharya method	64.18 (9.244)	0.274 (0.092)	-0.681 (0.359)	3.052 (0.641)	0.9790
1998	Wetherall	65.126	0.298	-0.451	3.102	0.9980

Table (5) Growth parameters of Mugil cephalus of Egypt (Bardawil Lagoon) and other localities

Author	Locality	Method	Sex	Length	L_∞	K	t_o	Φ
Erman, 1959	Mediterranean, Turkey	Otoliths	Sp.	TL	71.5	0.254		3.11
Jingm & Misra, 1962	India	Tagging	Sp.		140.0	0.150		3.47
Thompson, 1963	Australia	Scales	Sp.	TL	72.7	0.230	0.006	
Morovic, 1984	Mediterranean, Yugoslavia	Scales	Sp.	NG	48.5	0.310		2.86
Ih-Hsiu Tung, 1970	Taiwan	Scales	M	TL	49.8	0.395	0.050	2.99
			F	TL	59.3	0.301	-0.120	3.02
Marquez, 1974	Mexico	Scales	Sp.	TL	51.0	0.340	-0.114	
Cech & Wohlschlag, 1975	Texas, USA	Scales	M	TL	40	0.367	-0.480	2.77
			F	TL	42.2	0.327	-0.700	2.77
Farrugio, 1975	Mediterranean, Tunisia	Scales	M	TL	46.6	0.29		2.84
			F	TL	54.6	0.2		2.78
Pauly, 1979	Mediterranean, Turkey	Length Frequency	Sp.	TL	105	0.11		3.08
Diaz & Hernandez, 1980	Mexico	Scales	Sp.	TL	58.6	0.19	-0.213	
Bebars, 1986	Bardawil Lagoon	Scales	M	TL	54.3	0.433	-0.618	
			F	TL	79.22	0.341	-0.337	
Wijeyaratue & Costa, 1987	SriLanka	Scales	Sp.	TL	89.7	0.094		2.86
Annala, 1994	NewZealand	Scales	M	FL	35.8	0.47		2.78
			F	FL	40.1	0.45		2.86
Ibanez Aguirre et al, 1999	Mexico	Otoliths	M	TL	60.4	0.11	-2.979	
			F	TL	62.3	0.11	-2.67	
Present study	Bardawil Lagoon	Scales	Sp.	TL	74.2	0.246	-0.969	

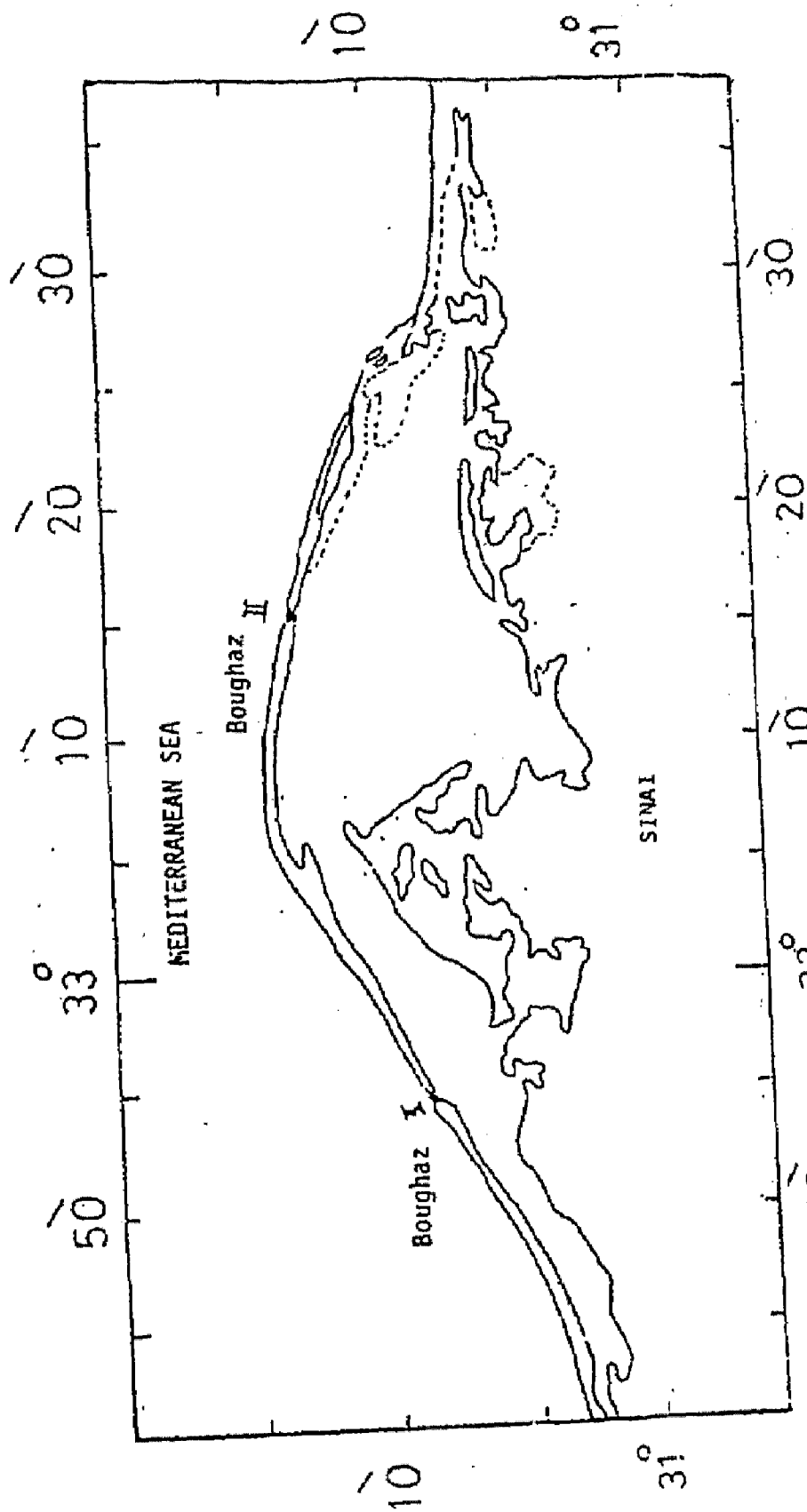

Fig.(1): The Bardawil Lagoon.

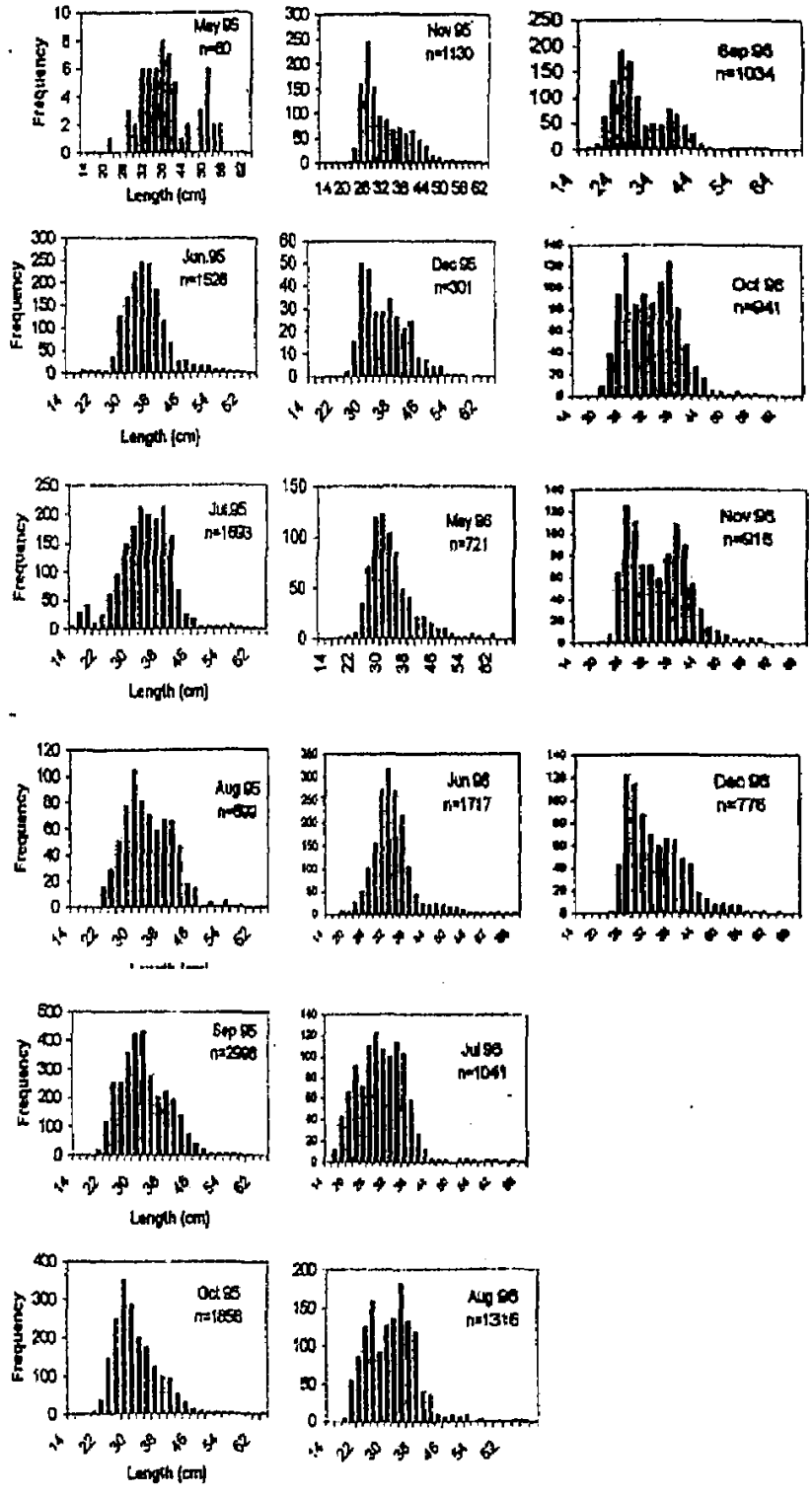

Fig (2) length frequency distributions of *Mugil cephalus* from Bardawil lagoon during the fishing seasons 1995 and 1996.

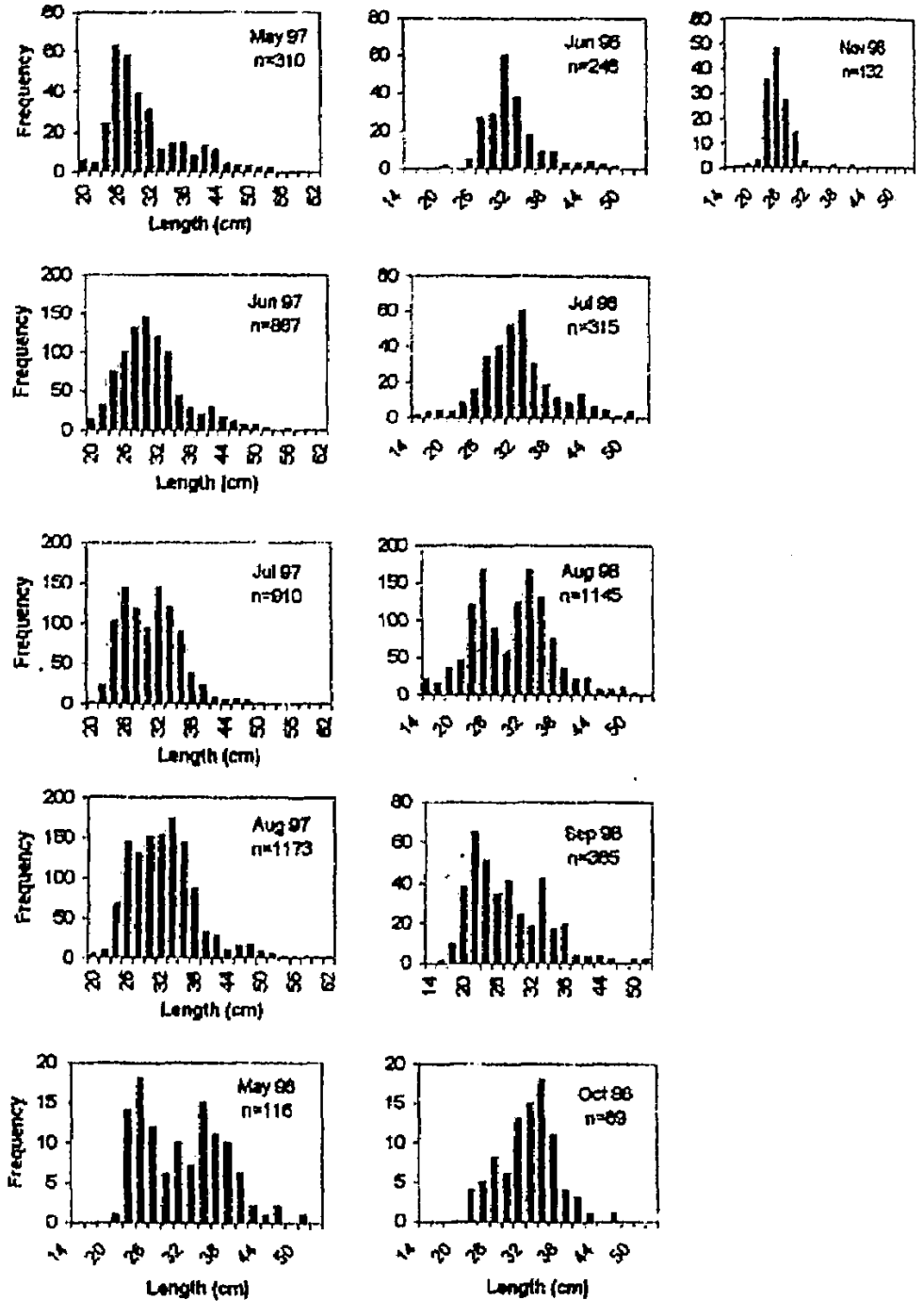

Fig (3) length frequency distributions of *Mugil cephalus* from Bardawil lagoon during the fishing seasons 1997 and 1998.

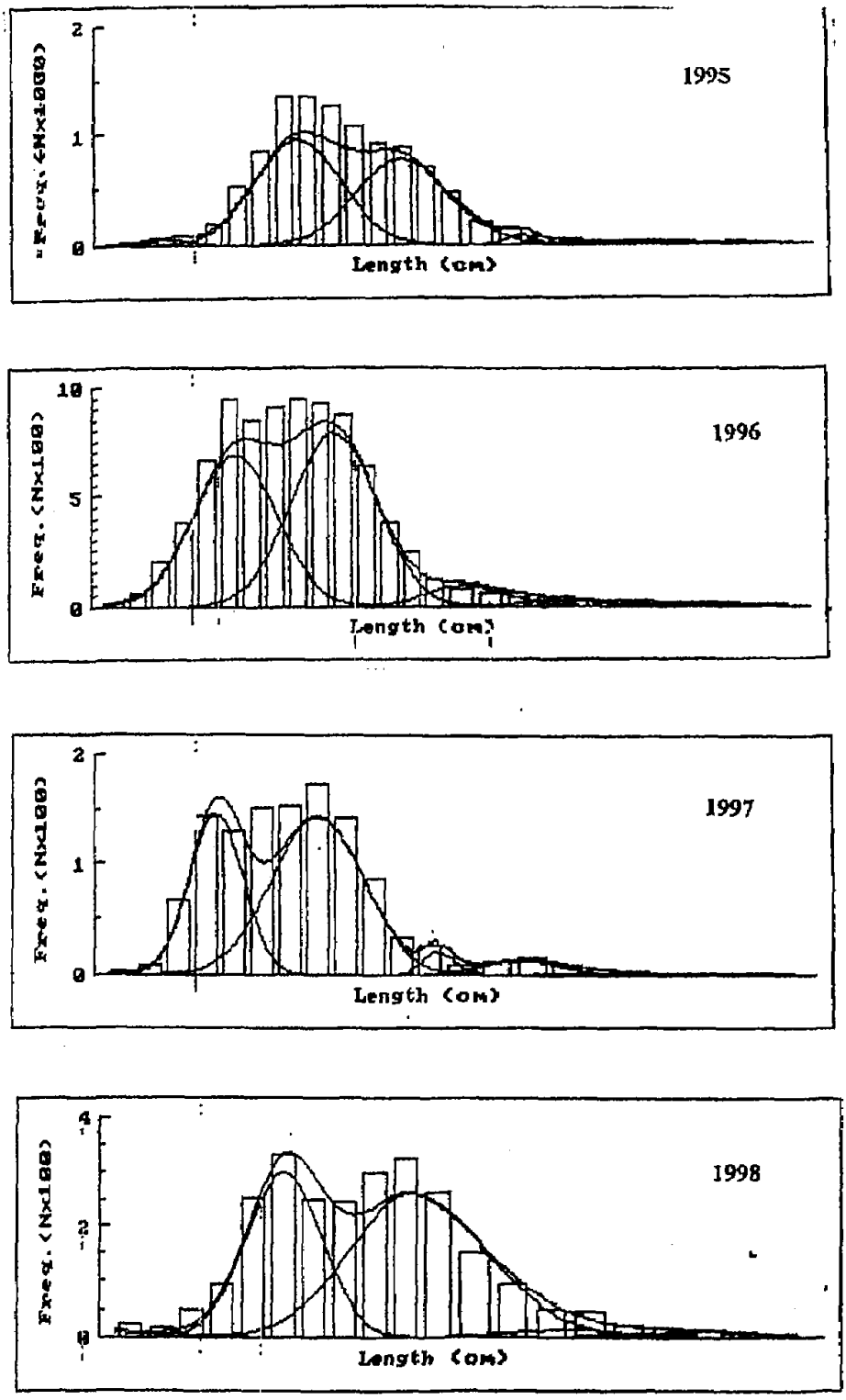

Fig (4) Seasonal length frequency distributions of *Mugil cephalus* with modal length groups as obtained from Bhattasharya method.

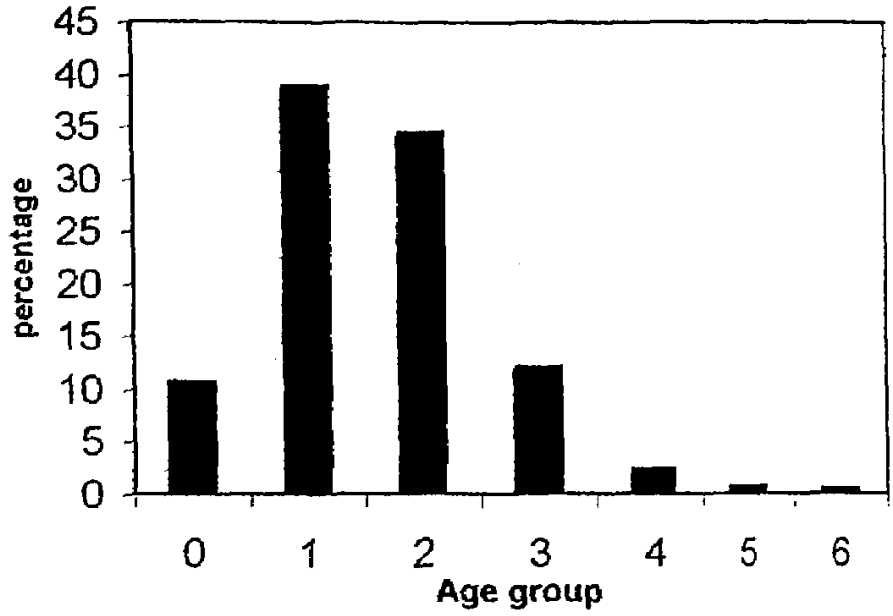

Fig (5) Age composition of *Mugil cephalus* in Bardawil lagoon

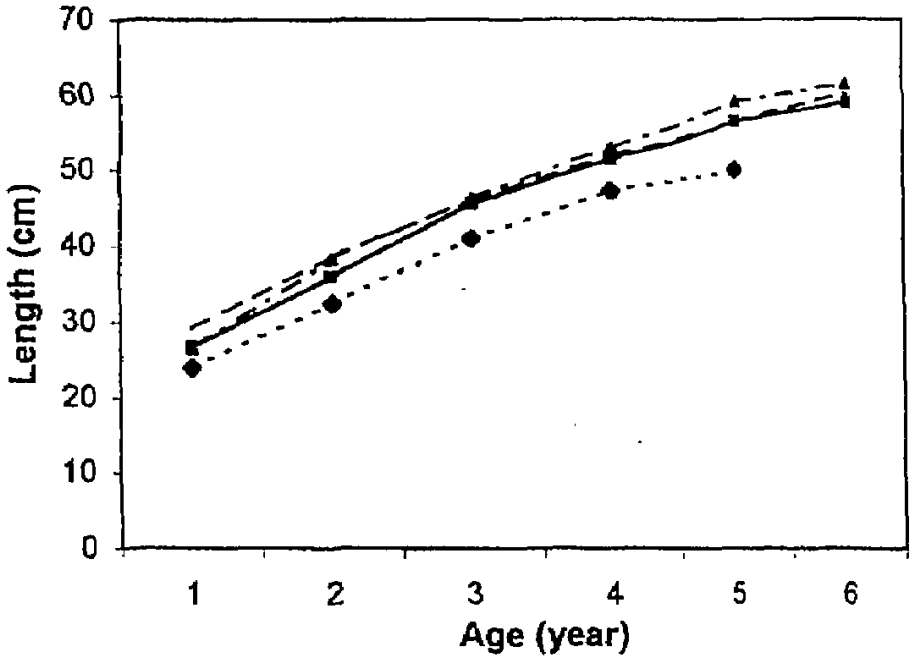

Fig (6) Theoretical growth curve of Mugil cephalus in four sucsessive years (1995-1998).