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Age determination and growth of leaping mullet, (*Liza saliens* R.1810) from the Messolonghi Etoliko lagoon (western Greece).

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Abstract

This study is the first detailed work on the age and growth of the leaping mullet (Liza saliens, Risso 1810) in the central Mediterranean. During the period 1991-1995 the age and growth of leaping mullet from the Messolonghi -Etoliko lagoon system (western Greek coast) were studied. Age and growth determinations were based upon otolith samples taken from 537 fish. Marginal increment analysis was used to validate age determination. Annulus formation took place around November each year. The back-calculated lengths at age estimated from the otoliths showed no differences between sub-areas of the lagoon system and the recorded limited between-years variability showed no persistent temporal pattern. The maximum age of leaping mullet in the Messolonghi - Etoliko lagoon was 5 years for males and 6 years for females. The von Bertalanffy equation (L_∞=32.99±1.25 cm, k=0.258 ±0.017 year^{-1}, t_0=-0.47±0.04 year) accurately describes the growth of the total length of leaping grey mullet for all life stages (fry, juveniles and adults). A large spread and length overlap characterized the age groups. The estimated Length-Weight relationships were common for the two sexes (W=0.0079L$^{3.01}$).

Keywords: *Liza saliens*, Mugilidae, leaping mullet, age and growth, Western Greece.

Introduction

The leaping mullet (*Liza saliens*, Risso 1810, Pisces: Mugilidae) is abundant around the Mediterranean, the Black Sea coast and along the Atlantic coast from Morocco to the Bay of Biscay (TREWAVAS, 1979). It is also present in the Caspian Sea (BEN TUVIA, 1986) and in the brackish water lakes of Egypt (EL ZARKA & KAMEL, 1965).

Mullet and mullet products have considerable economic importance at a regional level, especially around the Mediterranean. The leaping mullet constitutes an important part of their production. It is one of the least studied Mugilids in the central and eastern Mediterranean. Information on its biology comes mainly from studies carried out in the western Mediterranean (CAMBRONY, 1983), southeastern Mediterranean (ZAKY-

RAFAIL, 1968; El ZARKA & EL SEDFY, 1970; EL ZARKA *et al.*, 1970; PELMUTTER *et al.*, 1957) and eastern Mediterranean (KOUTRAKIS & SINIS, 1994; KOUTRAKIS *et al.*, 1994; KAYA *et al.*, 2000). The other references to this species are from the Black Sea (ALEEV, 1956-cited by THOMSON, 1966), the european Atlantic coast (DRAKE *et al.*, 1984 a,b) and the Balearic Islands (CARDONA, 1999 a,b). Most of this information concerns age, growth, morphological character, feeding and seasonal occurrence.

The studies conducted in the central Mediterranean examine morphological characters (MINOS *et al.*, 1994; MINOS *et al.*, 1995; MINOS *et al.*, 2002), seasonal occurrence of fry, the spawning period of the species (KATAVIC, 1980; KATSELIS *et al.*, 1994; MICKOVIC *et al.*, 1994), feeding habits (TORRICELLI *et al.*, 1988; TOSI and TORRICELLI, 1988) and dynamic of population (CONIDES *et al.*, 1992). In this region, only one study presented information on the age and growth (GIATNISI, 1985), but the estimates were of low accuracy.

Age and growth are important input parameters for stock assessment techniques.

This work is the first detailed study on these parameters of leaping mullet in the Messolonghi-Etoliko lagoon, a typical Mediterranean lagoon, (western Greece, central Mediterranean).

Materials and Methods

The Messolonghi Etoliko lagoon system is located along the coast of western Greece (38°18'N-21°32'E), and is situated in the northern part of the Patraikos Gulf. It has a total surface area of about 150 Km^2 and is one of the larger lagoon systems in the Mediterranean. Based on the topography, hydrology and fish species composition, six sub-areas can be defined (DIMITRIOU *et al.*, 2000a) (Fig.1). Except for its northern part (Etoliko lagoon), the lagoon has an average depth of 0.8m and the bottom is covered with

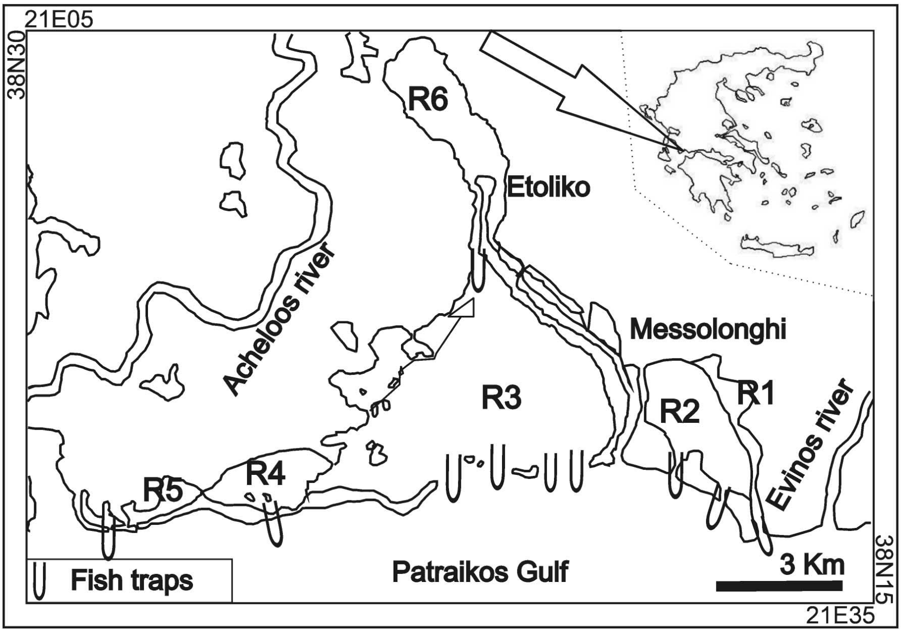

Fig 1: The area of study. Letters R1 to R6 indicate the different areas composing the Messolonghi-Etoliko lagoon system.

rich vegetation. The Etoliko lagoon has an average depth of 12m and a maximum depth of 33m. The water temperature ranges from 9-32° C (DIMITRIOU *et al.*, 2000b) and the salinity from 15-45 psu.

Exploitation is a common, extensive culture, based on seasonal entrance to the lagoons and summer-to-winter offshore fish migration. The fish are caught in barrier traps in fenced areas separating the lagoon from the sea. Gill nets and dip nets are also used in the lagoon all year long.

During the period from January 1991 to December 1995, samples of leaping grey mullet were collected on a monthly basis from four sub-areas (R2, R3, R5 & R6) of the Messolonghi-Etoliko lagoon system (Fig. 1). A total sample of 1133 specimens was caught using a variety of different types of equipment. 973 specimens were caught in barrier traps, 137 specimens by trammel nets and 23 specimens with total length of less than 100 mm, by 12 x 1.2 m mosquito purse seine.

Total length (L) and standard length (LS) were measured to the nearest mm, total body weight (W) to the nearest 0.01 g and the sex was determined in mature specimens by gonad colour: orange for females and white for males, while otoliths were removed from the fish. Age determination from otolith readings was performed on 537 randomly collected fish monthly. Otoliths were read under a binocular stereoscope with a 25x magnification, using transmitted light. The opaque zone was used for ageing, the distances from the otolith nucleus to the rostrum (maximum radius), and the radius (distance from the otolith nucleus to the opaque zone edge, in the same direction of maximum radius) of each ring were measured with an optical micrometer. In otoliths presenting reading difficulties in the region near the focus (mainly from adult individuals), matter was removed from the surface layers of the bezel side of the otolith by smoothing with 50μ sandpaper.

The marginal increment index $I_M = 100^*(Rc-Rn)/Rn$, was calculated, where Rn is the radius of the last growth ring n and Rc is the maximum otolith radius.

Relationships between total otolith radius (Rc) and total length (L) were determined for males, females and the sexes combined. Regression analysis was employed and the significance of the recorded differences was tested by an analysis of covariance (ANCOVA). Back-calculated lengths at the estimated age of individual fish were estimated from the log transformation length-otolith radius regression. Differences in back-calculated length at age groups between the age, the sexes, years of sampling and sub-areas were tested by analysis of variance (ANOVA) (ZAR, 1984).

The von Bertalanffy growth equation was fitted to back-calculated length at age data using a non Linear Regression Analysis.

Results

The 1133 leaping mullet collected during the period 1991-1995 ranged from 4 to 29.1 cm total length. From these, 268 individuals were identified as male, 216 as female and in 649 immature individuals sexes were not identified. The overall ratio of males to females was 1: 0.8 and χ^2 analysis ($P>0.05$) revealed this to be not significantly different from the expected 1:1 ratio. Females ranged from 15 to 29.1 cm total length and males from 12 to 24.1 cm (Fig. 2). The regression equations of the interconversion of L to LS are expressed linearly and the slopes of the equation did not differ significantly between the sexes ($F=0.16$, $P>0.05$). The relationship for the sexes combined is: $L=0.456+1.234LS$ ($R^2=0.96$, $SEest=0.74$) where SEest is the standard error of estimates.

The analysis of covariance showed no significant difference between the males and females in the Length-Weight relationship ($F=0.14$, $P>0.05$). The obtained equation for both sexes is the following: $W=0.0079L^{3.01}$

(R^2=0.97, SEest=0.11), where *W* is expressed in g and *L* in cm.

Age and growth determinations were based upon otolith samples of 537 fish. Ring reading was impossible in 42 (7.9%) of them. The unreadable otoliths were uniformly distributed throughout the fish size range. The maximum number of detected rings was 6 for males and 7 for females.

The mean marginal increment index for the age group II, III and IV showed that one ring was formed per year. The largest percentage of individuals with a ring at the edge of the otolith was found in the November samples (Fig. 3).

The analysis of covariance showed no significant difference between the males and females in the L-Rc relationships ($F=4x10^{-6}$, $P>0.05$). Thus, for the estimation of back-calculated lengths at each age (Table 1) we used the relationships obtained from the total sample ($ln(L)=-2.13+1.19\ ln(Rc)$, $R^2=0.98$, SEest=0.083).

Analysis of variance confirms that for the age groups O to V, there are no significant differences between age groups and sexes for the back-calculated mean length at each age from otoliths ($P>0.05$). The first ring was formed in otoliths at an average length of 3.8 ±1.32 cm. The spawning period of leaping

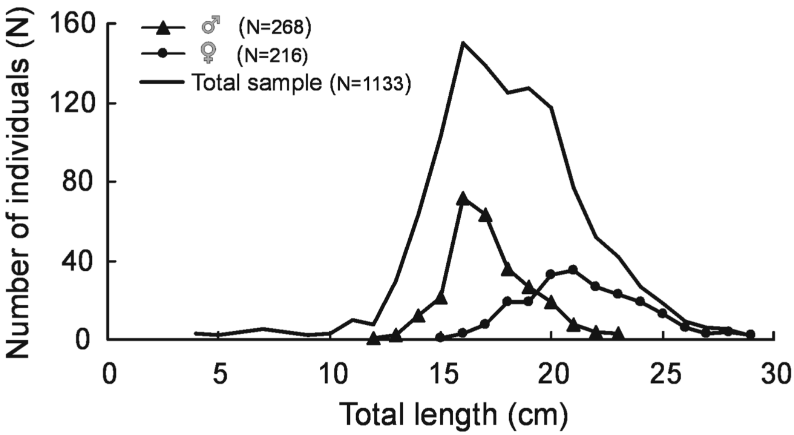

Fig 2: Total length (*L*) frequency distribution by sex for the sampled leaping mullet individuals.

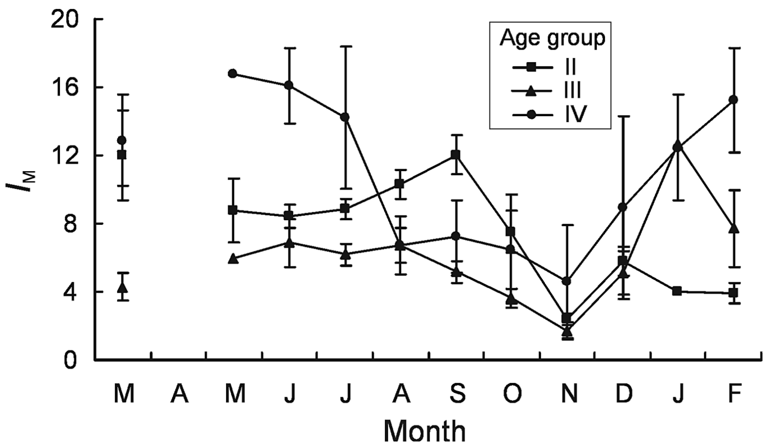

Fig 3: Monthly changes in the marginal increment index (I_M) estimated from the age groups II, III and IV.

Table 1
Average back calculated lengths (cm) for each ring in each age group.

		Otolith rings						
	Age group	**1**	**2**	**3**	**4**	**5**	**6**	**7**
	O	3.53						
	I	3.74	10.81					
	II	3.71	10.38	15.68				
	III	3.86	10.42	15.56	19.57			
	IV	4.91	10.55	15.77	19.37	22.37		
	V	4.72	10.19	15.74	19.69	22.83	25.49	
	VI		10.04	15.50	19.48	22.71	24.57	26.58
	F	2.1	1.51	0.34	0.49	0.88	3.43	
	P	0.06	0.18	0.84	0.68	0.42	0.07	
	Mean	3.81	10.44	15.65	19.53	22.50	25.38	26.58
	SD	1.32	1.09	1.35	1.20	1.40	0.84	0.97
	n	198	454	415	225	82	24	3
	growth	11.44	6.63	5.21	3.88	2.97	2.88	1.20
Males	Mean	3.7	10.4	15.8	19.5	21.0	25.1	
	SD	1.5	1.1	1.4	1.5	1.5		
	n	39	82	81	26	4	1	
	growth	11.19	6.7	5.4	3.7	1.5	4.2	
Females	Mean	4.08	10.44	15.84	19.54	22.46	25.38	25.46
	SD	1.52	1.06	1.09	1.03	1.47	1.03	
	n	7	145	146	113	41	13	1
	growth	12.23	6.36	5.40	3.70	2.92	2.92	0.07
	F	1.37	0.041	2.3	0.09	3.85	0.059	
	P	0.24	0.84	0.63	0.75	0.06	0.81	

n is the number of otolith readings, SD is standard deviation, F is F-ratio and P is significant level.

mullet begins in May-June and the greatest frequency of specimens with a total length between 35-70 mm appeared in the coastal waters of Messolonghi from October - December (KATSELIS *et al.*, 1994). Thus, it can be assumed that the first ring is formed 4-5 months after spawning and consists of the 'fry ring'. The individuals that have only this ring formed the O age group. From the results presented above and the marginal increment analysis results, the 1st ring is formed on the otoliths at an age of 4-5 months, the 2nd at 16-17 months and the rest follow at 12 monthly regular intervals.

The back-calculated lengths at age between years also presented some variability. In fact, an analysis of variance showed that for the age groups I to III there were significant differences between years (Table 2), but these differences do not show a persistent temporal pattern. In fact, the smaller group I individuals sampled in 1994 produce the longer mean values the next year. Also, ANOVA confirms that for age groups O to V, there are no significant differences between sub-areas ($P>0.05$) for the back-calculated mean length at each age from otoliths.

The growth rate was calculated using the von Bertalanffy growth equation and the coefficients of the growth are presented in Table 2. The 95 % confidence intervals of the von Bertalanffy growth equation parameters overlap between the years of sampling, which means that their parameters showed no significant differences. The ratio of L_{max}/L_∞ (L_{max} is the maximum observed length in the sample) was 0.88. The estimated value of t_0 was -0.47 ± 0.032 year (5.18-6.1 months) and can be considered as the time needed to form the first ring ('fry ring') in otoliths.

Table 2
Size and age composition of males, females and immature individuals of leaping mullet from Messolonghi -Etoliko lagoon.

	year of sampling							
Age group	**1991**	**1992**	**1993**	**1994**	**1995**	**n**	**F**	**P**
O	3.09	4.26	3.36	4.18	3.88	197	1.82	0.13
I	10.4	10.7	10.13	9.9	10.49	450	5.048	0*
II	15.28	15.68	14.9	15.03	15.97	411	11.05	0*
III	19.07	19.61	18.9	18.92	19.75	221	5.068	0*
IV	22.45	22.9	21.43	23.76	22.41	78	2.46	0.04*
V	25.08	25.42	25.14	26.42	25.69	20	0.54	0.71
N	44	113	102	29	205			
Observed range of L	11.1-29.1	4.5-28.4	4.2-28.7	12.8-23	11.5-26.6	All sampling		
L_∞ (cm)	31.8±5.02	35.1±3.7	32.5±3.07	47.2±23.9	32.37±1.77	32.99±1.25		
k (year^{-1})	0.27±0.09	0.23±0.05	0.25±0.03	0.14±0.1	0.27±0.03	0.26±0.017		
t_0 (year)	-0.44±0.17	-0.57±0.12	-0.45±0.08	-0.64±0.34	-0.46±0.04	-0.47±0.03		
n	122	278	228	69	705	1401		
R^2	0.94	0.93	0.95	0.92	0.95	0.95		

* Significant difference, N is number of specimens, n is the number of length-age readings for back calculation, F is F-ratio and P is significant level.

A length-age key for the two sexes and their combination is presented in Table 3. The age groups were characterised by a large spread and overlapping of length.

Discussion

Studies of the age and growth of fish are essential for the management of their stocks. Grey mullet make up the most important part of the fish catch in the Messolonghi - Etoliko lagoons. The mean annual production is about 1300 – 1500 mt and is provided by 200 fishermen working at the barrier traps and 700 fishing in the lagoon. Mullet are estimated to compose 45 % of the total fish catch (KOTSONIAS, 1984; DIMITRIOU *et al.*, 1994). Separate catch statistics for each species are available only for barrier trap fish catches. During the period 1995-1998, 182 mt of fish per year was caught in the barrier trap of the Messolonghi -Etoliko lagoons, 51.9 % of which were mullet. Among the five mullet species caught barrier trap, *L. saliens, Liza aurata* and *Mugil cephalus* were more abundant (18.8%, 14.3 % and 10.7 % respectively) than *Liza ramada* (5.7%) and *Chelon labrosous* (2.4%)(KATSELIS, unpublished data).

Various methods are used to determine the age in Mugilidae. Some authors preferred using length frequency analysis (DRAKE *et al.*, 1984a; CARDONA, 1999a), but QUIGNARD and FARRUGIO (1981) claimed that these methods were useless for mullet because of the difficulty of obtaining samples, and because spawning takes place over several months.

Both scales and otoliths are used for the age determination of Mugilidae. To use otolith, or any other structure, for age determination, the deposition of regular detectable age marks is essential. Otolith age determination is considered to be more accurate because otoliths have a higher priority in utilization of calcium (CARLANDER, 1987). However the otoliths have rarely been used in mullet because of the difficulty in reading the rings in the region near the focus of the otolith (ERMAN, 1959; KENNEDY & FITZMAURICE, 1969; BRULHET, 1974). THONG (1969) indicated that only 67%, 66% and 64% of the otoliths of *L. ramada, C. labrosus* and *L. aurata* respectively were readable in the above-mentioned studies.

Table 3
Size and age composition of males, females and immature individuals of leaping mullet from Messolonghi -Etoliko lagoon.

L (cm)	males					females					immature							
	I	II	III	IV	V	II	III	IV	V	VI	O	I	II	III	IV	V	VI	total
4-5											10							10
5-6											3							3
6-7											10							10
7-8											6							6
8-9											5							5
9-10												2						2
10-11											4	2						6
11-12											1	5						6
12-13												1	2					3
13-14												5	8					13
14-15												5	11					16
15-16		3										9	16	1				29
16-17	1	12										7	23					43
17-18	1	14				2	1					3	16	1				38
18-19		12	3			6	2						8	8				39
19-20		10	3			11	8						14	9				55
20-21		3	8	1		9	14						5	10	3			53
21-22		2	6			4	19	5						6	4			46
22-23				1		1	15	5						7	5	1		35
23-24			1	1	1		7	5						6	5	1		27
24-25			1				3	9	2						3	2		20
25-26							2	2	1						5	1		11
26-27							1		3						1	2		7
27-28								1	2	1					1	1	1	7
28-29								1	3								1	5
29-30									1									1
Total	**2**	**56**	**22**	**3**	**1**	**33**	**72**	**28**	**12**	**1**	**39**	**39**	**103**	**48**	**27**	**8**	**2**	**496**

This difficulty was verified in the present study and it was partially overcome by smoothing the bezel side during the preparation of the otolith. The percentage of reliability of otolith readings in this study was 92.1%. Following the same technique KAYA *et al.* (2000) have increased the percentage of reliability of otolith readings to 87.7%. According to our findings, otolith readings gave correct results and fitted the growth equation well(Table 2).

The results of the study of the marginal increment index suggest that rings in leaping mullet are formed annually around November, when the water temperature in the lagoon is between 14 and 21°C (DIMITRIOU *et al.*, 2000b). Thus, the annual ring formation is related to the decrease of the growth rate of the species in water temperatures lower than 20°C (CARDONA, 1999a) and minimal feeding activity (CARDONA, 1999b). In addition, 'fry ring' formation is possibly caused by changes in the proteinic composition due to the different diet that they adopt (from zooplankton to mixed and finally to vegetarian) (ALBERTINI-BERHAUT, 1974; DE SILVA, 1980). Other researchers agree that the formation of the annual ring of mullet takes place in winter, but in scales this ring is detected in spring (CAMBRONY, 1983; KOUTRAKIS & SINIS, 1994).

The length overlap between successive age classes is expected for species with an extended reproductive period. The reproduction period of leaping mullet in western Greece occurs from May to November (KATSELIS *et al.*, 1994). This fact reduces the ability to use the length frequency analysis for age estimation (BAGENAL & TESCH, 1978). However, the population of leaping mullet fished in the Messolonghi-Etoliko lagoon system consists of individuals of different ages, which inhabit several biotopes with various levels of trophic importance for fish in adjacent areas of the Ionian Sea and the Gulf of Patras and which enter the lagoons each spring. Thus, a high variability in length at age is expected due to several growth rates. This mechanism could partially explain the fact that between the sub-areas of the lagoon system there were no differences in lengths at age, the variability of length at age among the years and the length overlap between successive age classes.

There are six age classes of leaping mullet in the Messolonghi – Etoliko lagoons. The oldest specimens observed in Mediterranean lagoons (Porto Lagos lagoon: N. Greece) attained an age of eight years (KOUTRAKIS & SINIS, 1994), while maximum age estimates in coastal waters of western Greece was 5 years (CONIDES *et al.* 1992) and in other localities ranges from 3-5 years.

The von Bertalanffy equation obtained in this study appeared to be an accurate description of growth in length of leaping mullet for all stages of its life (fry, juveniles and adults). In our computation the asymptotic total length of the leaping mullet was $L_\infty=32.99\pm1.25$ cm and $k=0.258\pm0.017$ year^{-1}. From other *Liza* species in the Messolonghi –Etoliko lagoons the leaping mullet was estimated to have a smaller L_∞ and greater k value. For *L. aurata* in the same region the von Bertalanffy values have been estimated $L_\infty=69.6$ cm, $k=0.136$ year^{-1} (HOTOS, 1999), while for *L. ramada* $L_\infty=56.3$ cm, $k=0.179$ year^{-1} (MINOS, 1996). These findings were in agreement with those in Porto Lagos lagoon (KOUTRAKIS & SINIS, 1994).

Table 4 shows the results obtained by other studies concerning the age determination of leaping mullet. Most of the values of L_∞ and k for leaping mullet that inhabit various Mediterranean localities fluctuate between 30 and 39 cm and 0.23 and 0.30 year^{-1} respectively. The majority of the extreme values of L_∞ and k are due to the method for the estimation of the length at age or the sample quality. For the leaping mullet inhabiting the Loutsa lagoon (Epirus: NW Greece), GIATNISI (1985) estimates L_∞ equal to 42.3 cm and k equal to 0.16 year^{-1} an implication of the overestimation of L_3 due to small size of the samples (3 specimens). For this reason as well, there are extreme values of von Bertalanffy equation parameters in the SE Mediterranean where the older ages (L_4, L_5) were demonstrated by 1-2 specimens (EL ZARKA & EL SEDFY, 1970; EL ZARKA *et al.*, 1970), or the overestimation of the lengths at age in older ages due to the length frequency analysis used (DRAKE *et al.*, 1984a; CARDONA, 1999a).

From the results shown above it is clear that the growth rates of leaping mullet from different localities can be compared only for young stages and only in some cases (e.g. the debatable results discussed above should not be accepted). Thus, the growth rate of the young leaping mullet (1 to 3 years) in the Messolonghi -Etoliko lagoons is lower than the rates recorded in the other regions of the Mediterranean coastal areas and lagoons (the lagoons of the Gulf of Lions, north and eastern Aegean and the Egyptian coasts). Similar growth patterns of leaping mullet were observed in the Black Sea and finally, the growth of leaping mullet is slightly lower in the Lakes Edku and Quarun in Egypt than in the Messolonghi - Etoliko lagoon (Table 5).

Despite the above, we should expect the water temperature to affect growth in length (or weight) patterns of leaping mullet related to latitude because this species does not grow at water temperatures lower than 20°C (CARDONA, 1999a). The different growth rates of leaping mullet in different locations can be assigned to other factors apart from temperature differences, such as local food availability and/or density-dependent relations (EL ZARKA *et al.*, 1970; DRAKE *et al.*, 1984b). Feeding of mullet is connected to

Table 4
Average back calculated lengths (cm) for each year at age and estimate of von Bertalanffy growth equation parameters (± standard error) for year of sampling and all sampling of leaping mullet from back calculated length at age data set.

Total length (Li) at age i														
Region	Method	Sex	$L1$	$L2$	$L3$	$L4$	$L5$	$L6$	$L7$	$L8$	L_∞	k	$t0$	Author
W. Greece lagoons	Ot, vI_M	M	10.5	15.77	19.49	20.98	25.16				29.9	0.30	-0.42	
Messolonghi Etoliko	Ot, vI_M	F	10.4	15.8	19.5	22.4	25.4	26.4			32.9	0.25	-0.50	Present study
	Ot, vI_M	B	10.5	15.6	19.4	22.7	24.6	26.6			32.9	0.26	-0.47	
Loutsa lagoon (Epirus)	Sc	B	9.9	14.4	21.1α	22.5					42.3	0.16	-0.82	GIATNISI, (1985)
Porto Lagos lagoon	Sc, vI_M	M	11.5	17.8	22.1	25.0	27.4	30.7	32.2		33.8	0.32	-0.34	KOUTRAKIS
(N. Greece)	Sc, vI_M	F	11.4	18	22.4	25.8	28.2	30.5	32.1	33	36.7	0.28	-0.40	& SINIS, (1994)
	Sc, vIM	B	11.4	17.9	22.3	25.6	28.1	30.3	32	33	36.7	0.28	-0.34	
Lake Vistonida	Sc, vI_M	B	11.4	17.9	21.8	25.6	28.1				36.7	0.28	-0.34	
	Sc	M	8.1	13.8	18.9	22.8	26.3				45.2	0.17	-0.17	
W. Mediterranean	Sc	F	8.1	13.8	18.8	23.5	27.7				66.2	0.10	-0.27	EZZAT, (1965)**
(France: Lions Gulf)	Sc	B	9.2	16.5	22.2	26.2					38.4	0.29	-0.62	CAMBRONY, (1983)
Atlantic coast (Spain)	Pt	B	6.8	18.3	23.4	26.7	28.5				29.9	0.66	-0.14	DRAKE *et al.*, (1984a)
Balearic Islands	Pt	M	10.2	16.1	18.1	19.3	22.6				34.25	0.26	-0.44	
	Pt	F	10.2	16.1	19.3	22.6	26.5	29.1			38.7	0.20	-0.31	CARDONA, (1999a)
SE Mediterranean (Egypt)	Sc	B	7.6	18.7	23.6	28.0	32.0				36.4	0.44	0.52	ZAKY-RAFAIL, (1968)
Lake Quarun (Egypt)	Sc	M	12	16.5	20	24	27.5				36.9	0.23	-0.75	EL ZARKA & EL SEDFY, (1970)
	Sc	F	12	16.5	22	27	31				53.6	0.14	-0.82	
Lake Edku (Egypt)	Sc	M	8.2	13.5	16.7						21.5	0.50	0.05	EL ZARKA *et al.*, (1970)
	Sc	F	9	14.5	17.6						21.6	0.57	0.06	
E. Mediterranean	Ot	M	10.2	15.7	19.8	22.9	25.1	26.8			31.59	0.29	-0.41	
(Turkey: NE Aegean)	Ot	F	9.5	15.5	20.0	23.4	25.7	27.7	29.0		33.0	0.29	-0.38	KAYA et al., (2000)
	Ot	B	9.8	15.6	19.9	23.2	25.6	27.5	28.8		33.1	0.28	-0.38	
Black Sea	?	B	8.7	14.5	17.9	20.9	23	25.8			32.00	0.26	-0.26	ALEEV, (1956)#

cited by THOMSON (1966) , **cited by QUIGNARD & FARRUGIO (1981)

Table 5
Growth rate of young leaping mullet in different regions.

Total length (Li) at age i					
Region	$L1$	$L2$	$L3$	**Increment from 1 to 3 year (cm)**	**Author**
Lake Quarun (Egypt)	12	16.5	20	8	EL ZARKA & EL SEDFY,
Lake Edku (Egypt)	8.2	13.5	16.7	8.5	EL ZARKA *et al.*, (1970)
Messolonghi (W. Greece: Ionean Sea)	10.5	15.6	19.4	8.9	Present study
Black Sea	8.7	14.5	17.9	9.2	ALEEV, (1956)#
E. Mediterranean (Turkey: NE Aegean)	9.8	15.6	19.9	10.1	KAYA *et al.*, (2000)
Lake Vistonida (N. Aegean)	11.4	17.9	21.8	10.4	KOUTRAKIS & SINIS, (1994)
W. Mediterranean (Lions Gulf)	8.1	13.8	18.9	10.8	EZZAT, (1965)**
Porto Lagos lagoon (N. Aegean)	11.4	17.9	22.3	10.9	KOUTRAKIS & SINIS, (1994)
W. Mediterranean (France: Lions Gulf)	9.2	16.5	22.2	13	CAMBRONY, (1983)
SE Mediterranean (Egyptian coastal)	11	18.7	23.6	12.6	ZAKY-RAFAIL, (1968)

cited by THOMSON (1966) , **cited by QUIGNARD and FARRUGIO (1981)

primary productivity because these fish feed mainly on algae and diatoms, though they consume zooplankton and zoobenthos as well (BRUSLE, 1981). Thus, the lower growth rate which was estimated in this study can be attributed to the fact that the greater sea region of the Messolonghi - Etoliko lagoons is characterised by lower primary productivity values than the north and northeastern Aegean seas (DRAKOPOULOS, *et al.*, 2000) and Gulf of Lions (LEFEVRE, *et al.*, 1997).

Growth in length was similar for males and females, even though females were predominant in the older age groups (Table 3). Previous workers have found both significant (EL ZARKA & EL SEDFY, 1970) and non-significant differences (KOUTRAKIS & SINIS, 1994; KAYA *et al.*, 2000) in the growth rates of leaping mullet. This disagreement has been found for other Mugilidae species but in these cases the females live longer than males and are predominant in the older age groups (QUIGNARD & FARRUGIO, 1981). The small number of males at older ages can be related to the significant differences in length among the sexes. For example, in the first study (EL ZARKA and EL SEDFY, 1970), the L_4 and L_5 was estimated from one male, in contrast to other studies (KOUTRAKIS & SINIS, 1994; KAYA *et al.*, 2000) where the number of male specimens of these ages was greater. This hypothesis is supported by findings for other Mugilidae species in the Mediterranean (KOUTRAKIS & SINIS, 1994; MINOS, 1996; HOTOS, 1999).

Finally, the slope of the length-weight relationship (b=3.01≈3), shows that leaping mullet in the Messolonghi –Etoliko lagoons presented an isometric growth pattern.

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