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GROWTH ANALYSIS OF *Mugil cephalus* (PERCOIDEI: MUGILIDAE) IN MEXICAN CENTRAL PACIFIC

Elaine Espino-Barr[1], Manuel Gallardo-Cabello[2], Arturo Garcia-Boa[1], Marcos Puente-Gómez[1]

[1]Instituto Nacional de Pesca - Manzanillo, Playa Ventanas s/n, Manzanillo, Colima, 28200, México, Tel: 01 (314) 33 32 37 50; Fax: 01(314) 33 32 37 51.
[2]Instituto de Ciencias del Mar y Limnología, UNAM, Apartado Postal 70-305, México, D.F., 04510, México.

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Growth analyses are important in the study of the life history of all species, especially if it belongs to a fishery. The striped mullet *Mugil cephalus* is an appreciated fish in the small scale fishery. Specimens for this study were obtained from the commercial fishery in the Cuyutlan Lagoon, Colima, and in Cruz de Loreto Lagoon, Jalisco, Mexico; they were fished with gill-nets. Samples were obtained from August to December 2007, January to March 2008 and November 2012 to October 2013. Total length (TL, cm) was measured to the nearest millimeter, from the snout tip to the caudal fin extreme, and total weight (TW, g) and eviscerated weight (EW, g) were taken from 734 organisms. Growth constants from von Bertalanffy were determined with Ford-Walford-Gulland method. Growth parameters for the species were L_∞ = 60.0 cm, k = 0.115, t_o = -2.63, TW_∞ = 2 147 g, EW_∞ = 1 782 g and longevity $A_{0.95}$ = 23.5 years. Differences were found in the growth of sexes. Allometric indexes of the relationship between weight and length were isometric: b = 2.954 for TW data and b = 2.95 for EW data. Results were compared to those of other authors in other geographic areas in Mexico and the world, finding differences probably due to climate, genetic and latitudinal position, as well as to the fishing pressure. *M. cephalus* is a slow grower whose juvenile organisms have to be protected, by using the appropriate fishing gears.

Key words: Growth in weight, length weight relationship, longevity, sagittae and asterisci, von Bertalanffy.

INTRODUCTION

The striped mullet *Mugil cephalus* Linnaeus, 1758 has a worldwide distribution between 42°N and 42°S (de Silva, 1980). This species is important for the meat consumption and the "roe" (female mature gonads), which reaches a higher price than the meat: the roe is $ 300.00 Mexican pesos ($ 18.00 US dollars) and the meat $ 30.00 Mexican pesos ($ 1.80 US dollars).

M. cephalus ranks in 22nd place in Mexican fisheries, with a capture of 12 280 t (SAGARPA, 2015). This species has been studied in many parts of the world where well established fisheries are located. In the case of Mexico, analysis have been carried out on this fishery and biological aspects; the most important are: Márquez-Millán (1974), García (1980), Díaz-Pardo and Hernández-Vázquez (1980), Romero and Castro (1983), Pérez-García and Ibáñez-Aguirre (1992), Ibáñez-Aguirre and Lleonart (1996), Ibáñez-Aguirre and Gallardo-Cabello (1996a), Sánchez-Rueda *et al*. (1997), Briones-Ávila (1992, 1998), Gallardo-Cabello *et al.* (2012). However, most of the studies in Mexico have been carried out in the Tamiahua lagoon, Tamaulipas, on the Atlantic Ocean, or in Mazatlán, Sinaloa and Nayarit on the northern Mexican Pacific Ocean. In the coast of Jalisco and Colima, *M. cephalus* does not

*Corresponding autor. E-**mail**: elespino@gmail.com

reach a high catch volume as in these other places, but it is important to know the health status of their populations. Traditionally *Mugil curema* is fished in a higher amount in the coasts of Jalisco and Colima, than *M. cephalus*. In 2014 *M. curema* was fished up to 626 tons (79% of the total Mugilidae species, and 167 tons of *M. cephalus* (21% of the total Mugilidae species) (SAGARPA, 2015). Therefore *M. curema* has been analyzed and some studies of its population dynamics are: Espino-Barr *et al*. (2005), Gallardo-Cabello *et al*. (2005), Ibáñez-Aguirre *et al.* (2006), Cabral-Solís *et al*. (2007), Cabral-Solís *et al*. (2010), Espino-Barr *et al*. (2013). This study is the first of *M. cephalus* growth carried out in the area of Colima and Jalisco. According to the above, in this study the following objectives are reviewed:

a) Calculate the values of the growth constants in length and weight by means of the von Bertalanffy equation.
b) Analyze differences in the growth per sex.
c) Obtain the values of the allometric indexes in the weight-length relationship.
d) Calculate longevity.
e) Compare growth parameters of this species from other areas in Mexico.

MATERIAL AND METHODS

The specimens were obtained from the commercial fishery in the Cuyutlan Lagoon, Colima, Mexico (103°57'-104°19' W and 18°57'-19°50' N) and in Cruz de Loreto Lagoon, Jalisco, Mexico (105º27'-105º33' W and 19º58'-20º05' N). The fishing gears were gill-nets of 2.0, 2.5, 3, 3.5 and 4 inches mesh size (5.08, 6.35, 7.62, 8.89 and 10.16 cm). Samples were obtained from August to December 2007, January to March 2008 and November 2012 to October 2013. Total length was measured to the nearest millimeter, from the snout tip to the caudal fin extreme in 734 organisms.

For the growth study, two persons examined sagittae and asterisci of 214 organisms independently. The identification of growth rings was done observing the sagittae and the asterisci in the stereoscopic microscope with transmitted light and the average length of the fish was calculated.

The otolith analysis allowed the identification of 10 age groups (age 1: 20.30 cm; age 2: 25.50 cm ± 0.566 standard error (S.E.); age 3: 28.70 cm ± 0.071 S.E.; age 4: 31.71 cm ± 3.818 S.E.; age 5: 34.50 cm ± 3.863 S.E.; age 6: 37.15cm ± 2.969 S.E.; age 7: 39.70 cm ± 3.628 S.E.; age 8: 42.00 cm ± 6.219 S.E.; age 9: 44.00 cm ± 1.414 S.E.; age 10: 46.00 cm ± 2.486 S.E.

Relations between total length of the fish, and length and width of the otoliths showed that these structures can be used to determine the age in fish (Gallardo-Cabello *et al*., 2012).

These mean lengths were used to calculate the von Bertalanffy (1938) growth equation; L_∞, k and t_o were obtained combining the methods of Ford (1933), Walford (1946) and Gulland (1964). Growth was also calculated for each sex and the curves were obtained for each method and evaluated the goodness of fit with the sum of the square difference (Σe_i^2). Hotelling's T^2 test (Bernard, 1981; Zar, 1996) was used to compare growth curves of the two sexes. This test assumes that estimation of von Bertalanffy growth equation parameters for both groups was obtained from two normal distributions of joint probability, with three variables and one common variance.

The total (TW, g) and eviscerated (EW, g) weight of 784 specimens (weighed to the nearest 0.1 g) was used for the growth analysis by weight. The function $W = a \cdot L^b$ was used to obtain weight-length relationship. Data for growth by length and the weight-length relationship were used to obtain the weight for each age. The growth of weight was obtained substituting length and L_∞ by weight and W_∞, respectively in the von Bertalanffy equation.
Taylor's equation (1958, 1960) was used to calculate age limit or longevity (95% of L_∞).

RESULTS

Biometrics Relationship

The maximum value of total length (TL, cm) was 57 cm and the minimum was 10.0 cm with a difference of 47 cm (Table 1, Figure 1). Total weight (TW, g) varied from 10.41 to 1,777.69 grams.

Data of the relationships between length, height and weight are shown in Table 2.

There were no significant differences between sexes in the case of TL vs standard length (SL, cm),and TL vs height (He, cm) ($F_{(1, 169)} = 1.72$), but in the case of TL vs TW and TL vs eviscerated weight (EW, g), differences between sexes were significant $F_{(1, 167)} = 4.893$.

Time of growth rings formation

Figure 2 shows that the percentage of otoliths with fast growth bands is higher during autumn-winter, from September to February, while otoliths with slow growth bands are shown during spring-summer, March to August.

Length growth

Growth parameters obtained by Ford-Walford-Gulland methods for TL were L_∞= 60.00 cm, k = 0.115, t_o = - 2.63. Observed and calculated values for each age group are shown in Table 3 and Figure 3.The growth from age cero to the age 1 was 4.81 cm; 4.29 cm from age 1 to age 2; 3.82 cm from age 2 to age 3; 3.41 cm from age 3 to age 4; 3.04 cm from age 4 to age 5; 2.71 cm from age 5 to age 6; 2.42 cm from age 6 to age 7; 2.15 cm from age 7 to age 8; 1.92 cm from age 8 to age 9 and 1.71 cm from age 9 to age 10.

Table 1: Summary of size values of the measured variables.

	SL (cm)	TL (cm)	He (cm)	TW (g)	EW (g)
Average	27.76	35.90	6.84	453.79	384.12
Maximum	47.08	57.00	10.59	1777.69	1504.53
Minimum	6.44	10.00	2.05	10.41	8.81
Standard Deviation	4.77	7.69	1.60	4.79	4.05
Mode	22.61	30.00	5.78	267.02	226.04

Note: SL = standard length, TL = total length, He = height, TW = total weight, EW eviscerated weight, N = 784.

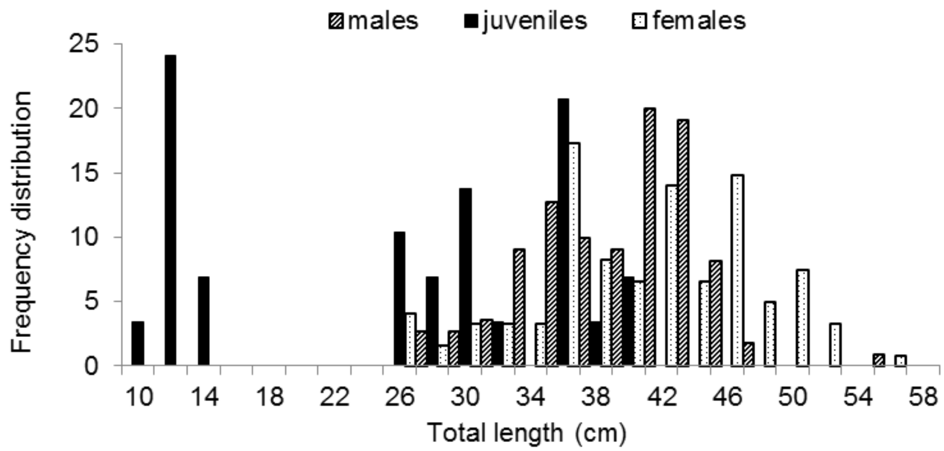

Figure 1: Frequency distribution of total length of *Mugil cephalus.*

Growth in weight

The allometric growth weight value of the weight-length equation was an isometric index: b = 2.954 for TW data (t = 259, $p > 0.05$) and b = 2.95 for eviscerated specimens (t = 194.73, $p > 0.05$) (Table 2 and Figure 4).

Theoretical growth in weight

The calculated asymptotic total weight was TW_∞ = 2,147 g, and the eviscerated asymptotic weight was EW_∞ = 1,782 g. Observed and calculated values of TW for each age group are shown in Table 4 and observed and calculated values of EW appear in Table 5.

Longevity

M. cephalus reaches 95% of its infinite length in 23.5 years.

Differences between sexes

The allometric growth weight value of the weight-length equation was an isometric index in all cases: for total weight data, b = 2.995 in males (t = 89.058, $p > 0.05$) and b = 3.196 in females (t = 122.378, $p > 0.05$).These values for eviscerated males were: b = 2.884 (t = 80.447, $p > 0.05$), and b = 3.103 for eviscerated females (t = 108.092, $p > 0.05$) (Table 2).

Growth parameters obtained by Ford-Walford-Gulland methods for TL were L_∞ = 66.26 cm, k = 0.083, t_o = -2.984 for males and L_∞ = 63.27 cm, k = 0.109, t_o = - 2.860 for females.

Observed and calculated values for each age group are shown in Table 3 and Figure 3.

The calculated asymptotic total weight was TW_∞ = 2,879 g for males and TW_∞ = 2,511 g for females; and the eviscerated asymptotic weight was EW_∞ = 2,389 g for males and EW_∞ = 2,084 g for females. Observed and calculated values of total weight for males and females are shown in Table 4, and observed and calculated values of eviscerated weight for males and females appear in Table 5.

The Hotelling's T^2 test (Bernard, 1981; Zar, 1996) showed that the growth of females and males is different ($F_{0.05(2,10 = 4.19)}$ = 432.1).

Longevity in males is reached at 33.1 years and 24.5 years in females.

Comparison of growth parameters values of *M. cephalus* in different localities

The parameters of the von Bertalanffy growth equation for *M. cephalus* in different areas of Mexico and the world are shown in the Table 6.

Table 2: Morphometric relationships of the variables TL, SL.

		a	b	R^2	F
TL vs SL	All	0.464	1.143	0.830	1085.9
	Females	0.813	0.991	0.968	2565.6
	Males	0.715	1.024	0.955	1793.5
TL vs He	All	0.233	0.944	0.924	2617.0
	Females	0.097	1.182	0.813	357.7
	Males	0.099	1.174	0.769	274.5
TL vs TW	All	0.012	2.954	0.971	7512.8
	Females	0.005	3.196	0.942	1382.2
	Males	0.010	2.995	0.905	801.0
TL vs EW	All	0.010	2.953	0.952	4139.9
	Females	0.006	3.103	0.932	1131.2
	Males	0.012	2.884	0.892	695.0

Note: TL = total length, SL = standard length, He = height, TW = total weight, EW = eviscerated weight, N = 784, females = 86, males = 85.

Table 3: Observed and calculated values of total length (cm) for each age group (years) for: species, females and males.

	Species		Females		Males	
Age (years)	**observed**	**calculated**	**observed**	**calculated**	**observed**	**calculated**
0		15.62		16.99		14.55
1	20.40	20.43		21.79		18.67
2	25.50	24.71	25.40	26.08		22.46
3	28.70	28.53	28.00	29.93	30.80	25.95
4	31.71	31.94	33.25	33.39	33.51	29.16
5	34.50	34.98	36.86	36.48	37.58	32.12
6	37.15	37.69	37.75	39.26	37.43	34.84
7	39.70	40.11	41.85	41.75	39.55	37.35
8	42.00	42.26	43.48	43.97	42.19	39.65
9	44.00	44.18	45.00	45.97	44.65	41.77
10	46.00	45.90	47.63	47.77	46.60	43.72
11		47.42		49.37		45.52
12		48.79		50.81		47.17

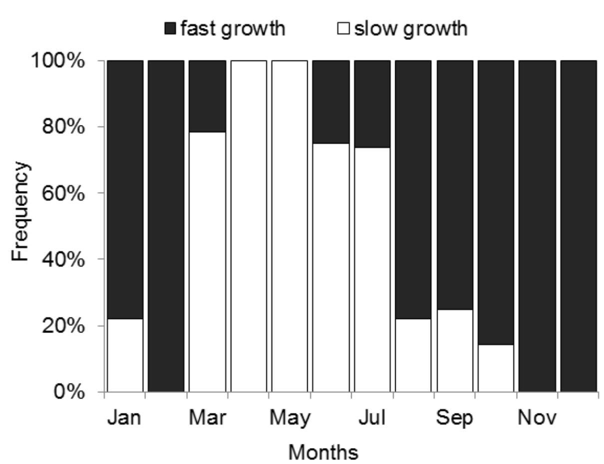

Figure 2: Monthly frequency of the slow growth and fast growth borders in the *Mugil cephalus* sagittae and asterisci.

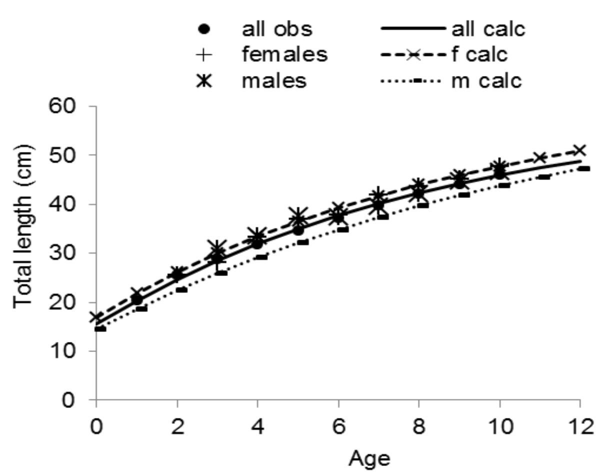

Figure 3: Von Bertalanffy's growth curve in length for *Mugil cephalus*, for all and sexes.

Table 4: Observed and calculated values of total weight (g) for each age group (years) for: species, females and males.

	Species		**Females**		**Males**	
Age (years)	**observed**	**calculated**	**observed**	**calculated**	**observed**	**calculated**
0		40		52		33
1	89	89		108		68
2	171	156	169	183		118
3	243	239	226	275	299	181
4	326	333	375	380	384	255
5	419	436	509	494	539	339
6	521	544	546	613	533	431
7	634	653	741	735	627	529
8	749	762	829	857	759	632
9	859	869	918	978	897	737
10	979	973	1,085	1,095	1,018	843
11		1,072		1,207		950
12		1,165		1,314		1,055

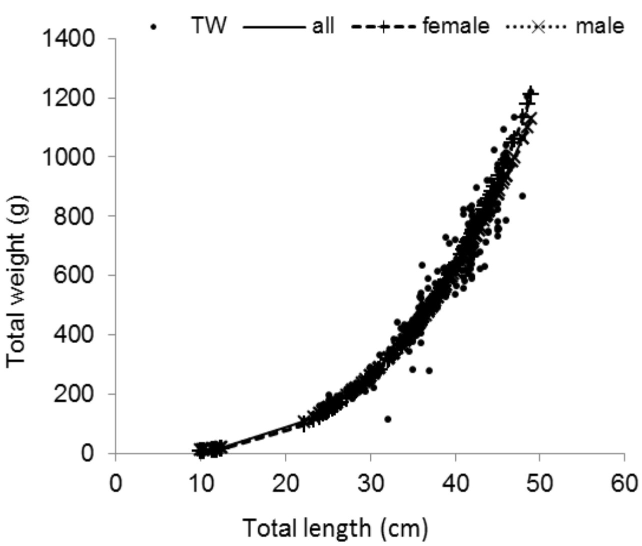

Figure 4: Weight-length relation by potential model of *Mugil cephalus.*

DISCUSSION

The analysis of the last growth band in the otoliths, sagittae and asterisci, showed that each year a band of slow growth and another of fast growth are formed, validating age estimation based on the number of rings in the otoliths of *M. cephalus*.

In this study the Ford-Walford-Gulland method showed a very good adjustment to the observed data. Applying other methods such as the Newton algorithm in Solver (Microsoft, 1992), underestimated the asymptotic length, without showing a better adjustment. We believe this may be because the Ford-Walford-Gulland method does not need as many requirements regarding the characteristics of the samples and the biases they could present.

Briones-Ávila (1992, 1998) found the L_∞ values in the coastal lagoons of Sinaloa and Nayarit, higher than those reported in this study, 61.0 cm and 61.8 cm (Table 6). Also, the L_∞ value obtained in this study, 60 cm, is higher than on the coasts of Chiapas in the Mexican Pacific, of 48.85 cm, by Romero and Castro (1983). Similarly, the index value k = 0.21, obtained in Chiapas is higher than the found in this study (k = 0.11). This phenomenon, in which the average lengths for each age found in *M. cephalus* in this study are higher than those reported for the state of Chiapas, can be related to the phenomenon reported by Taylor (1958), who establishes that for the same species, variations in its von Bertalanffy parameters are determined by the latitude and temperature, being lower the L_∞ and higher the k index, as the organisms approach the equator.

In relation to another locality of Mexico, this one located in the Atlantic Ocean, we observed that Taylor's (1958) statement also holds: In the Tamiahua lagoon, where L_∞ = 64.24 cm is higher than the found in the present study, and with k = 0.10 (Ibáñez-Aguirre *et al.* 1999), slightly lower than reported in this study. However, other authors reported lower values of L_∞ and higher of the k index, than those found by Ibáñez-Aguirre *et al.* (1999), in Tamiahua lagoon, as those reported by Márquez-Millán (1974): L_∞ = 51 cm, k= 0.34; Díaz-Pardo and Hernández-Vázquez (1980): L_∞ = 58.80, k = 0.19; and Díaz-Ramos (1992): L_∞ = 48.20 cm, k = 0.254. These differences could also be due to the different structures used for the identification of the growth rings, as Ibáñez-Aguirre and Gallardo-Cabello (1996b) reported that otoliths give better results than scales for the age determination of *M. cephalus*.

Also worth mentioning is the fact that the number of age groups found in *M. cephalus* in this study of 10 growth rings is higher than the 6 rings reported in the Tamiahua lagoon, which can be related to fishing pressure, since the fishery of *M. cephalus* in Tamaulipas state is more intense than in the coasts of Colima and Jalisco. Only in the Tamiahua lagoon in the year 2013 a total of 2,961 tons of *M. cephalus* were fished and 3,201

Table 5: Observed and calculated values of eviscerated weight (g) for each age group (years) for: species, females and males.

	Species		Females		Males	
Age (years)	observed	calculated	observed	calculated	observed	calculated
0		33		43		27
1	74	74		89		57
2	142	130	141	152		98
3	202	198	188	229	249	150
4	271	277	312	316	319	212
5	348	362	423	410	447	282
6	433	451	453	509	442	358
7	526	542	615	610	520	439
8	622	633	688	712	630	524
9	713	722	762	812	745	612
10	813	808	901	909	845	700
11		890		1,002		788
12		967		1,091		876

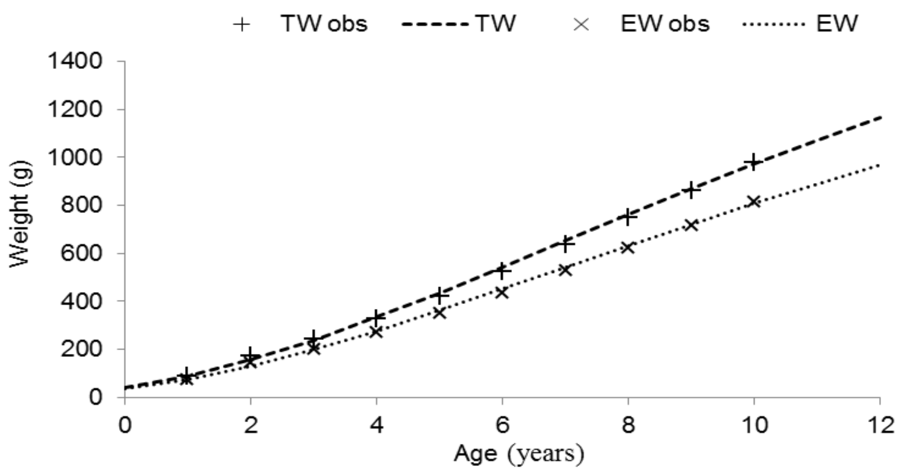

Figure 5: Von Bertalanffy's growth curve in total and eviscerated weight for *Mugil cephalus.*

tons average in the last five years. In 2013, in the coasts of Jalisco and Colima, 67 tons were fished and an average of the last five years of 25 tons (SAGARPA, 2015). The pronounced differences in the amount of catches of *M. cephalus* in both locations show that in the Tamiahua lagoon the activity may have come to a progressive reduction in the age groups over 6 years, while in the coasts of Colima and Jalisco, older ages are being preserved. Moreover, it is important to mention that the largest catches of *M. cephalus* are achieved in the Pacific coasts; the national statistics in 2013 was of 9,898 tons, from which 4,469 (50.1%) were obtained in the Pacific Ocean and 4,448 (49.9%) in the Atlantic (SAGARPA, 2015). In the coasts of Jalisco and Colima only 1.18% of the Pacific capture is obtained, while the more important fishing areas are in the coasts of the Sinaloa and Nayarit.

It is also important to note that in this study females reached larger sizes than males at the same age, a phenomenon also described in *M. cephalus* in the Tamiahua lagoon (Ibáñez-Aguirre *et al.* 1999). However many authors found no differences in growth between sexes, such as Dannevig (1902), Kesteven (1942), Thomson (1951), Morovic (1957), Erman (1959), Thakur (1967), Czech and Wohlschlage (1975), Grant and Spain (1975). Other authors report differences in growth between sexes, but do not analyzed if these differences were statistically significant (Ibáñez-Aguirre *et al.* 1999).

Values of the allometric indexes of the weight-length relationship obtained in this study: b = 2.954 for total weight and b = 2.95 for eviscerated weight, differ from those obtained by Ibáñez-Aguirre *et al*. (1999) in Tamiahua, Veracruz (b = 2.80 for total weight and b = 2.86 for eviscerated weight).

Regarding longevity values, Table 6 shows that for localities in Mexico, males of *M. cephalus* from this study reach higher ages $A_{0.95}$ = 33.1 years than females. These were very similar to the longevity of females studied by Ibáñez-Aguirre *et al.* (1999) in Tamiahua, Veracruz ($A_{0.95}$ = 24.6 years) and $A_{0.95}$ = 24.5 years in Colima and

Table 6: Growth parameters and longevity ($A_{0.95}$) of *Mugil cephalus* in the coast of Mexican Pacific and other localities.

L_∞	k	to	$A_{0.95}$	sex	length	method	locality	Autor
60.00	0.115	-2.630	23.5	Sp.	TL	otoliths	Central Mexican Pacific	This study
63.27	0.109	-2.860	24.5	F	TL	otoliths	Central Mexican Pacific	"
66.26	0.083	-2.984	33.1	M	TL	otoliths	Central Mexican Pacific	"
62.29	0.110	-2.670	24.6	F	TL	otoliths	Tamiahua, Mexico	Ibáñez-Aguirre *et al*. (1999)
60.39	0.110	-2.979	24.3	M	TL	otoliths	Tamiahua, Mexico	"
64.24	0.100	-2.850	27.1	Sp.	TL	otoliths	Tamiahua, Mexico	"
61.80	0.320	-0.050	9.3	Sp.	TL	length freq	Agua Brava Lagoon, Nayarit, Mexico	Briones-Ávila (1998)
61.00	0.360	-0.950	7.4	Sp.	TL	length freq	Castal lagoons of Sinaloa	Briones-Ávila (1992)
48.20	0.254	n/m	11.8	Sp.	TL	n/m	Laguna de Tamiahua, Veracruz, Mexico	Díaz-Ramos (1992)
45.85	0.210	-1.770	12.5	Sp.	TL	scales	Chiapas, Mexico	Romero and Castro (1983)
58.80	0.190	-0.213	15.6	Sp.	TL	scales	Tamaulipas, Mexico	Díaz-Pardo and Hernández-Vázquez (1980)
51.00	0.340	-0.114	8.7	Sp.	TL	scales	Tamiahua, Mexico	Márquez-Millán (1974)
61.50	0.400	-0.044	7.4	Sp.	TL	scales	Orbetello, Italy	Alessio (1976)
40.70	0.320	-0.710	8.7	F	TL	scales	Texas, USA	Cech and Wohlschlag (1975)
45.00	0.240	-0.900	11.6	Sp.	TL	scales	Texas, USA	"
69.30	0.190	-0.630	15.1	Sp.	TL	scales	Tunisia	Farrugio (1975)
41.77	0.470	-0.169	6.2	Sp.	TL	otoliths	France	Ezzat (1964)
72.70	0.230	0.006	13.0	Sp.	TL	scales	Australia	Thompson (1963)
60.90	0.300	-0.143	9.8	Sp.	TL	scales	West Australia	Thompson (1951)
37.40	0.820	-0.160	3.5	F	TL	scales and tag	N and NW Florida, USA	Broadhead (1958)
37.90	0.660	-0.036	4.5	M	TL	scales and tag	N and NW Florida, USA	"
59.00	0.230	-0.083	12.9	Sp.	TL	scales	Vransko, Yugoslavia	Morovic (1957)
61.10	0.212	-0.465	13.7	Sp.	TL	scales	Venice, Italy	Morovic (1954)
108.90	0.050	-1.620	58.3	Sp.	TL	scales	Black Sea, Europe	Ilin (1949)
62.04	0.650	-0.048	4.6	Sp.	TL	scales	Tunisia	Heldt (1948)
172.90	0.060	-0.510	49.4	Sp.	TL	scales	Australia	Kesteven (1942)
56.30	0.560	0.083	5.4	Sp.	TL	scales	Rome, Italy	Serbetis (1939)

Note: taken from Ibáñez-Aguirre *et al*. (1999) and Briones-Ávila *et al*. (2000), longevity calculated by authors; n/m = not mentioned. TL = total length, F = females, M = males, Sp. = species.

Jalisco. However, the lowest values of longevity were obtained in Tamiahua by Márquez-Millán (1974) and Díaz-Pardo and Hernández-Vázquez (1980). Likewise, Romero and Castro (1983) reported a value of $A_{0.95}$ = 12.5 years in the coasts of Chiapas, a southerner locality in México. According to Taylor's (1958) statement, these stocks of *M. cephalus* show a higher value of the k index and therefore a lower asymptotic length and longevity.

CONCLUSIONS

1. Average length found for *Mugil cephalus* was of 35.90 cm, the minimum 10 cm and the maximum 57.00 cm. Average total weight was of 453.9 g, the minimum of 10.41 g and the maximum of 1,777.8 grams.
2. Each year a fast growth band and a slow growth band deposit on the otoliths of *M. cephalus*, equivalent to a year of age.
3. The values of the allometric indexes of the length weight relation were: b = 2.954 for TW data and b = 2.95 for eviscerated specimen.
4. The growth parameter found in this species are L_∞ = 60.0 cm, k = 0.115, t_o = -2.63, TW_∞ = 2,147 g, and EW_∞ = 1,782 g.
5. The number of age groups found for this species in the studied area was of 10 years.
6. Growth parameters per sexes were: L_∞ = 66.26 cm, k = 0.083, t_o = -2.984 for males and L_∞ = 63.27 cm, k = 0.109, t_o = - 2.860 for females.
7. Longevity values were $A_{0.95}$ = 23.5 years, for females $A_{0.95}$ = 24.5 years and for males $A_{0.95}$ = 33.1 years.

RECOMMENDATIONS

We found that it is important to continue age-growth studies of *M. cephalus* in the main capture zones, and also start them in those locations where the species is fished and no information is available.

In those zones of higher fishing rates, supervise the fishermen so that the regulation is respected, so that the resource can recover from the intense fishing activity.

It is also very important to stop the cutting of mangroves in the coastal lagoons, which affect the spawning and nursery areas of many fish species besides *M. cephalus*, and prevent the dumping of wastes that pollute these production zones, causing the death of many species of fish.

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REFERENCES

Alessio G (1976). Riproduzione artificiale e piscicoltura intensive di specieittiche marine come possibilita disfruttamento della laguna di Orbetello. Ateneo Prmenense, Acta Na 12: 315-332.

Bernard DR (1981). Multivariate analysis as a means of comparing growth in fish. J. Fish. Aquat. Sci. 38: 233-236.

Briones-Ávila E (1992). Diagnóstico de la pesquería de la lisa (*Mugil cephalus*) en Sinaloa. INP CRIP-Mazatlán. Boletín Informativo 25: 44-51.

Briones-Ávila E (1998). Biología y pesquería de *Mugil cephalus* en la Laguna de Agua Brava, Nayarit, durante 1992-1994. Tesis de Maestría. Facultad de Ciencias del Mar. Universidad Autónoma de Sinaloa, México.

Briones-Ávila E, Fuentes Mata P, Fernández Méndez JI (2000). Lisa del Pacífico. In: Cisneros-Mata MA, Beléndez Moreno LF, Zárate Becerra ME, Gaspar Dillanes MT, López González LC, Saucedo Ruiz C, Tovar Ávila J. Sustentabilidad y pesca responsable en México. Evaluación y manejo. Instituto Nacional de la Pesca, SAGARPA. 275-294.

Broadhead GC (1958). Growth of the black mullet (*Mugil cephalus* L.) in the W. and NW Florida. Florida St. BoardConserv. Mar. Lab. Tech. Ser. 25: 1-29.

Cabral-Solís EG, Espino-Barr E, Gallardo-Cabello M, Ibáñez-Aguirre AL (2007). Fishing impact on *Mugil curema* stock of multi-species gill net fishery in a tropical lagoon, Colima, Mexico. Journal of Fisheries and Aquatic Science 2(3): 235-242.

Cabral-Solís EG, Gallardo-Cabello M, Espino-Barr E, Ibáñez-Aguirre AL (2010). Reproduction of *Mugil curema* (Pisces: Mugilidae) from the Cuyutlán lagoon, in the Pacific coast of México. Avances de Investigación Agropecuaria 14(3): 19-32.

Cech JJ, Wohlschlag DE (1975). Summer growth depression in the striped mullet, *Mugil cephalus*. Contrib. Mar. Sci. 19: 92-100.

Dannevig HC (1902). The sea mullet, *Mugil dobula* Günther. Rep. Fish. NSW 2: 26-33.

de Silva SS (1980). Biology of grey mullet: a short review. Aquaculture 19: 21-36.

Díaz-Pardo E, Hernández-Vázquez S (1980). Crecimiento, reproducción y hábitos alimenticios de la lisa *Mugil cephalus* en la Laguna de San Andrés, Tamps. Anales de la Escuela Nacional de Ciencias Biológicas 23: 109-127.

Díaz-Ramos JAS (1992). Contribución al conocimiento de algunos parámetros biológico pesqueros de las lisas (*Mugil cephalus* L. 1758) en la Laguna de Tamiahua, Veracruz. Res. 4º Encuentro Académico de Estudiantes de Ciencias del Mar y Limnología. Inst. Cienc. Del Mar y Limnol. UNAM.

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

Espino-Barr E, Cabral Solís EG, Gallardo-Cabello M, Ibáñez-Aguirre AL (2005). Age determination of *Mugil curema* Valenciennes, 1836 (Pisces: Mugilidae) in the Cuyutlan Lagoon, Colima, Mexico. International Journal of Zoological Research 1(1): 21-25.

Espino-Barr E, Gallardo-Cabello M, Cabral-Solís EG, Puente-Gómez M, Garcia-Boa A (2013). Otoliths analysis of *Mugil curema* (Pisces: Mugilidae) in Cuyutlan Lagoon, Mexico. Avances de Investigación Agropecuaria 17(1): 35-64.

Ezzat A (1964). Contribution à l'étude de la biologie des Mugilidae de la región de l'étang de berre et de Port de Bouc. Rec. Trav. Stn. Mar. Endoume 47(31): 187-202.

Farrugio H (1975). Les muges (Poissons, Téléostéens) de Tunisie: répartition et peche. Contribution a leur ètude systematique et biologique. M.S. thesis, Universite des Sciences et Techniques du languedoc, Montpellier, France, 316 p.

Ford E (1933). An account of the herring investigations conducted at Plymouth during the years from 1924 to 1933. Journal of the Marine Biological Association of the United Kingdom 19: 305-384.

Gallardo-Cabello M, Cabral Solís EG, Espino-Barr E, Ibáñez-Aguirre AL (2005). Growth analysis of white mullet *Mugil curema* (Valenciennes, 1836) (Pisces: Mugilidae) in the Cuyutlán Lagoon, Colima, México. Hidrobiológica 15(3): 321-325.

Gallardo-Cabello M, Espino-Barr E, Cabral-Solís EG, Puente-Gómez M, Garcia-Boa A (2012). Study of the otoliths of *Mugil cephalus* (Pisces: Mugilidae) in Mexican Central Pacific. Journal of Fisheries and Aquatic Science 7(6): 346-363. ISSN 1816-4927. DOI: 10.3923/jfas.2012.

Gallardo-Cabello M, Espino-Barr E, Cabral-Solís EG, Puente-Gómez M, Garcia-Boa A (2012). Study of the otoliths of *Mugil cephalus* (Pisces: Mugilidae) in Mexican Central Pacific. Journal of Fisheries and Aquatic Science 7(6): 346-363. ISSN 1816-4927. DOI: 10.3923/jfas.2012.

García S (1980). Contribución al estudio de la pesquería de lisa (*Mugil cephalus* L) en la laguna de Tamiahua, Ver. INP de la Secretaría de Pesca, 28p.

Grant CJ, Spain AV (1975). Reproduction, growth and size allometry of *Mugil cephalus* L. (Pisces: Mugilidae) from North Queensland inshore waters. Aust. J. Zool. 23: 181-201.

Gulland JA (1964). Manual of methods of fish population analysis. FAO Fisheries Technical Paper 40:1-60.

Heldt H (1948).Contriburion à létude de la biologie des muges des lacs Tunisiens. Bull. Stn. Oceanogr. Salammbo 41: 1-35.

Ibáñez-Aguirre AL, Gallardo-Cabello M (1996a). Total and natural mortality of *Mugil cephalus* and *M. curema* (Pisces: Mugilidae), in Tamiahua Lagoon, Veracruz. I. Selectivity. Hidrobiológica 6(1-2): 9-16.

Ibáñez-Aguirre AL, Gallardo-Cabello M (1996b). Age determination of the grey mullet *Mugil cephalus* L. and the white mullet *M. curema* V. (Pisces: Mugilidae) in Tamiahua lagoon, Veracruz. Ciencias Marinas 22(3): 329-345.

Ibáñez-Aguirre AL, Gallardo-Cabello M, Chiappa-Carrara X (1999). Growth analysis of striped mullet, *Mugil cephalus,* and white mullet, *M. curema* (Pisces: Mugilidae) in the Gulf of Mexico. Fishery Bulletin 97: 861-872.

Ibáñez-Aguirre AL, Leonart J (1996). Relative growth and comparative morphometrics of *Mugil cephalus* L. and *M. curema* V. in the Gulf of Mexico. Scientia Marina 60(2-3): 361-368.

Ibáñez-Aguirre AL, Cabral-Solís EG, Gallardo-Cabello M, Espino-Barr E (2006). Comparative morphometrics of two populations of *Mugil curema* (Pisces: Mugilidae) on the Atlantic and Mexican Pacific coasts. Sci. Mar. 70(1): 139-145.

Ilin BC (1949). *M. cephalus* L., *M. auratus*, *M. salient* Risso. In: The industrial fishes of SSSR, Moscow, 49p.

Kesteven GL (1942). Studies on biology of Australian mullet. I. Account of the fishery and preliminary statement of the biology of *Mugil dobula* Gunter. Bull. Aust. CSIRO Melb. 157: 1-99.

Márquez-Millán R (1974). Observaciones sobre la mortalidad total y crecimiento en longitud de la lisa (*Mugil cephalus*) en la laguna de Tamiahua, ver., México. INP, Serie Científica 2: 1-17.

Microsoft (1992). Manual de usuario. Referencia de funciones. Microsoft Excel, USA, 702 p.

Morovic D (1954). Contribution à la connaissance annuelle de *Mugil cephalus* (L.) dans quelques "Valli de pesca" du litoral Venetien. Rap. P-V. Comm. Int. Explor. Sci. Mer. Mediterr. 12: 203-217.

Morovic D (1957). Les muges de l'Adriatique avec la bibliographie des muges. Inst. Zaslatkovodno Ribar. Zagreb.

Pérez-García M, Ibáñez-Aguirre AL (1992) Morfometría de los peces *Mugil cephalus* y *M. curema* (Mugiliformes: Mugilidae) en Veracruz, México. Rev. Biol. Trop. 40(3): 335-339.

Romero MAS, Castro JL (1983). Aspectos de la biología de la lisa (*Mugil cephalus* Linnaeus) en el Mar Muerto, Chiapas, México. An. Esc. Nac. Cienc. Biol., Méx. 23: 95-112.

SAGARPA (2015). Anuario estadístico de pesca 2014. Comisión Nacional de Acuacultura y Pesca, Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. http://www.conapesca.sagarpa.gob.mx/wb/cona/cona_anuario_estadistico_de_pesca

Sánchez-Rueda O, González-Mar I, Ibáñez-Aguirre AL, Márquez-García A (1997). Sedimento en el contenido estomacal de *Mugil cephalus* y *M. curema* (Mugiliformes: Mugilidae), en la laguna de Tamiahua, México. Rev. Biol. Trop. 45(3): 1163-1166.

Serbetis CD (1939). L'eta e l'accrescimiento dei Mugilidi. Boll. Pesca Piscic. Idrobiol. 15(6): 628-707.

Taylor CC (1958). Cod growth and temperature. Journal du Conseil 23(3): 366-370.

Taylor CC (1960). Temperature, growth and mortality – the Pacific cockle. Journal du Conseil 26(1): 177-124.

Thakur NK (1967). Studies on the age and growth of *Mugil cephalus* L. from the Mahanadi estuarine system. Proc. Natl. Inst. Sci. India (B) 33: 128-143.

Thomson JM (1951). Growth and habits of the sea mullet, *Mugil dobula* Günther in Western Australia. Aust. J. Mar. Freshwater Res. 2(2): 193-225.

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

von Bertalanffy L (1938). A quantitative theory of organic growth (inquiries on growth laws. Human Biology 10(2): 181-213.

Walford LA (1946). A new graphic method of describing the growth of animals. The Biological Bulletin 90(2): 141-147.

Zar JH (1996). Biostatistical analysis. 3rd ed. Prentice Hall. USA., 662p.