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Age and growth of the grey mullet (Pisces, *Mugilidae*) in Ria de Aveiro (Portugal)*

LUIS M. ARRUDA[1], JOSÉ N. AZEVEDO[2] and ANA I. NETO[2]

[1]Faculdade da Ciências de Universidade de Lisboa. Rua da Escola Politécnica, 58. 1294 Lisboa codex, Portugal.
[2]Departamento de Biologia da Universidade dos Açores. Rua da Mãe de Deus. 9502 Ponta Delgada codex. Portugal.

SUMMARY: Relative abundance and growth both in length and weight of the grey mullet in Ria de Aveiro were studied. The results showed that *L. aurata* was usually the dominant species throughout the year in each of three sampling zones. The juveniles of grey mullets migrated from the littoral zone to the lagoon in September-November. Moreover, the growth patterns showed a period of rapid growth during the spring and summer which declined or ceased for the next 5 or 6 months. There is an indication that temperature was important for growth in the early stages of growth.

Key Words: Age, growth, grey mullet, Ria de Aveiro (Portugal).

RESUMEN: EDAD Y CRECIMIENTO DE LOS MUGILIDOS (PISCES, *Mugilidae*) DE LA RÍA DE AVEIRO, PORTUGAL. Se estudiaron la abundancia relativa y el índice de crecimiento, tanto en relación a tamaño como a peso, de los mugílidos de la ría de Aveiro. Los resultados obtenidos indicaron que, normalmente y durante todo el año, *L. aurata* era la especie dominante en cada una de las zonas de muestreo. La migración de los mugílidos jóvenes, desde la zona litoral hasta la laguna, ocurría durante los meses de septiembre a noviembre. Por otra parte, los índices de crecimiento registraron un período de rápido desarrollo durante primavera y verano, que fue disminuyendo o cesó completamente en el transcurso de los cinco o seis meses siguientes. Hay, indicios de que la temperatura es un factor importante en la fase inicial del desarrollo.

Palabras clave: Edad, crecimiento, mugílidos, ría de Aveiro (Portugal).

INTRODUCTION

Grey mullets are coastal marine and less frequently freshwater fish; some of them seem capable of spending a great part of their life in fresh or brackish water and others only some months each year (QUIGNARD and FARRUGIO, 1981). They are among several marine fishes investigated to find suitable species for aquacultural purposes in brackish and freshwater ponds (CHERVINSKI, 1975a, 1975b and 1976; PERLMUTER *et al.*, 1957; TANG, 1975).

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Ria de Aveiro is a large marine lagoon system on the western coast of Portugal. Its importance for mariculture has been pointed out by other authors (*e. g.* HALL, 1980; HALL and DUARTE, 1984). Among the marine fish species referred to for possible culture in salt pans were grey mullets. However, this pratice has been hampered by lack of information.

This study is part of a research project with the aim of studying the ichthyological resources in Aveiro Lagoon, and was undertaken to obtain information on the abundance of grey mullets, including the seasonal occurrence of juveniles and the growth increase in both length and weight, and on the suitability of these species for stocking and rearing in the salt pans of Ria de Aveiro.

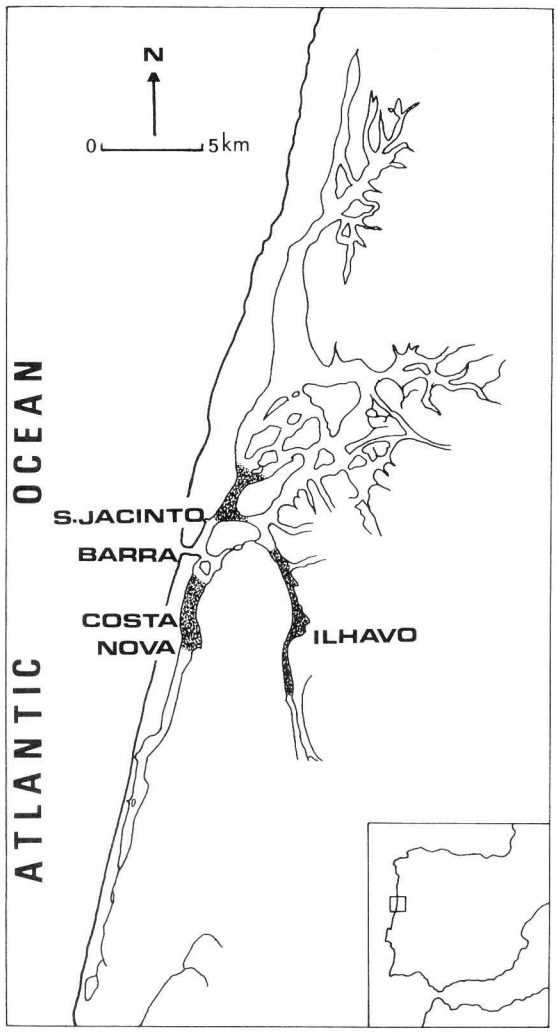

FIG. 1. — Map of the lagoon Ria de Aveiro, showing fishing zones (in black).

MATERIAL AND METHODS

In all, 6112 grey mullets were examined, namely, *Liza aurata* (Risso, 1918) (N = 3689); *L. ramada* (Risso, 1826) (N = 2174); *Chelon labrosus* (Risso, 1826) (N = 248) and *Mugil cephalus* (Risso, 1826) (N = 1).

Fish samples were collected monthly from November 1985 to October 1987 during morning low water tide. The three sampling zones are shown in figure 1. A standard 20 m long beach-seine was used. Between the edge and the centre the mesh size decreases from 2.5 cm to 2.0 cm. A conical net is set into the middle of the seine which has an even smaller mesh-size of 1.0-1.5 cm (*see* details in ARRUDA *et al.*, 1988). The seine was set from land and only allowed fish to escape when the lower edge lost contact with the bottom. Six hauls were made in each sampling zone at each sampling. Furthermore, a close homogeneity of fishing effort was achieved because this same number of hauls was always made during the sampling period. Both temperature and salinity of the surface water were registered before sampling.

The fish were identified by examining the pyloric caeca (PELMUTTER *et al.*, 1957; THONG, 1969; REAY, 1987). Total length of all fish was measured to the nearest mm and the specimens were subsequently grouped into 1 cm interval length classes (Table 1). Fish weight was determined to the nearest 0.1 g.

Scale samples for ageing were removed from the flanks below the first dorsal fin. As the youngest age-group was usually distinct from older fish on length-frequency plots, scale-reading was only used for checking the age of this group. Scales were examined from all order fish. As an age reference, the chronological appearance of the annulli was used. Monthly series including specimens ranging from the smallest to the largest ones captured were used to study the chronological appearance of the annulli. The scales of grey mullet in their second growing season (as determined by reference to size group analysis) show a fairly definite annulus, in the form of a hyaline line on the anterior sector and breaks in the pattern of the circuli elsewhere. The scales of specimens in their third growing season show that two annulli had been laid down. The annulli formed on the scales of older grey mullets are essentially similar in character to those on the scales of juveniles. Moreover, comparison of scales removed from the same specimen shows annulli in identical positions when referred to the nucleus. This chronological appearance of the annulli on the scales supports the point of view that only one annulus is formed yearly and validates the scale reading method for age determination. These observation agree with those of HICKLING (1970), KENNEDY and FITZMAURICE (1969) and THONG (1969).

For all species a 1st January birth-date was assumed because of the uncertainties about the true spawning season. BEN-TUVIA (1986) and THONG (1969) consider that *Liza* species spawn in summer-autumn months, but *C. labrosus* spawns in winter. This *Liza* species spawning period, however, is not compatible with the first recruitment in the lagoon that constitutes convincing, albeit indirect, evidence that the spawning season occurs well before. Moreover, this birth-date conveniently divided the life-history into discrete growth periods. Examination of the scales of the fish caught in the first winter after spawning also, revealed the existence of a valid 0-

TABLE 1. — Length-abundances data of the grey mullets collected in the Ria de Aveiro.

(A) *L. aurata*

length classes (cm)	*abundances* 85 Nov.	Dec.	86 Jan.	Fev.	Mar.	Abr.	May.	Jun.	Jul.	Oct.	Nov.	Dec.	87 Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.
2		2	2									2	5									6
3	5	24	40	1	8					16		12	38	29	2	1					1	10
4	7	14	38		4		1	1		2	2	15	96	14	6		2					7
5		6	3		2		9	1	2		1	1	1	19			3	1				
6							10	3	14	3							15	3		2		
7							4	8	77	8							45	15		35		
8								31	224	3	1						38	36	2	110		
9								39	110	2	1	1					4	70	5	9		
10								10	54	6	2		6					16	11	3		
11		1					1		23	20	4	5	5	5				2	14	17		
12									10	111	11	8	9	21	5	3			5	74		
13	5	1		1					1	114	50	45	24	52	29	17		1	1	56	2	
14	2	4	1	4	4		1		2	36	70	97	21	102	36	33	4	1		7	5	
15	9	8	9		18		12			7	33	90	18	66	15	6	29	12			4	1
16	13	17	7	4	9	1	15	9		4	9	22	2	17	4	1	29	12			2	
17	9	11	9		3		9	5	1		5	2	1	1		2	24	8			1	
18	3	7	3	2	2	1	1	13	8		1	1		2			5	4	1	4		
19	3	16	5	3	4		2	7	1				1	1		1	3	6	1	6		
20	1	21	15	10	9		3	4	1	1	5	1	3	6	1			2	1	9		
21	6	20	11	2	9			1	2	1	3	2	1	11	1	2				4	2	1
22	1	6	13	2	7	1	1	1	1			1	2	3						4	1	1
23	1	3	13		4			2	1			2	2	6							1	
24			6	1	1	1		1	1			1		4			1					
25			3	1								1										
26		1															2		1			
27			2									1					1			2		
28																				1		

(B) *L. ramada*

2			8		1							2	7			1						
3	1		12	1	2						1	5	33	3			1					
4	1		4									10	65	8			4					
5					1		3	1			5	40	12				1					
6									2		5	274	22	2			14	1		12		
7								3	2		14	35	10	1			38	16	2	104	1	
8								11	1	2	23	4	1	1		1	21	26		295	1	
9				1			2	9	1	7	48	6	1	1	3	19	5	52		158	2	
10		6	2				1	10		11	61	3	8	4		41	11	24		35	6	
11		5	2	1	1		5		1	4	19	3	4	5		37	59	4		3		
12		2			1		4	6	1	1	6	1	5	2		15	77	21	2	1		
13	2	1			1		4	13	9			2	2		1	5	36	13	1	4		
14			1					9	14			1			1	1	9	4		6		
15	1						1	2		2			1		2	2	1		1	7		
16	1	1	1					2							2		3					
17							1	1		1												
18	2						2															1
19								1														1
20			1								1											
21				2																		
22				1				1							1							
23																						
24																						
25																						
26							2															

(C) *C. Labrosus*

2			3		1																	
3			17							4												
4	1		4		1																	
5										1	19	1										
6							1				65	8	1									
7											16		1									
8											4											
9																						
10																	3					
11																	1	1				
14																			2			
15																			2	4		
16																			1	5	2	
17																				13	6	5
18																					10	4
19																					3	2
20																					3	7
21								1														9
22													1							8	1	2
23																					1	1
26													1									
29								1														
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33						1																

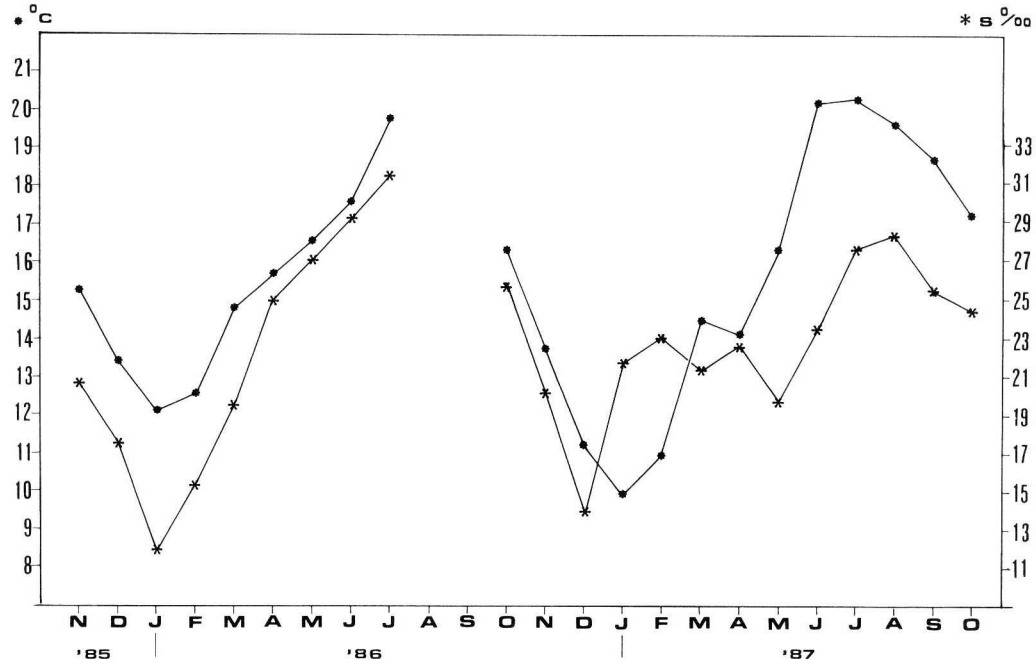

FIG. 2. — Variation in surface water temperature and salinity in the Ria de Aveiro expressed as mean values of the three sampling zones taken monthly.

group period prior to formation of the first growth-check.

The program Vonber (SPARRE, 1987) was used to estimate the growth parameters L_∞, K and t_0 in the ordinary von Bertalanffy equation: $L = L_\infty (1 - e^{-k(t+to)})$ from pairs of observed age and length in *L. aurata* and *L. ramada*. In *C. labrosus* only two age groups could be observed and so the growth parameters were not estimated. The program uses a non linear least squares procedure, where the estimates L_∞, K and t_0 are determined to minimize the sum of squared deviations between the observations and the estimated growth curve. The procedure is iterative and requires an initial guess of the parameters which were determined by the program. Data from all months were combined to estimate the weight/length equation ($W = a \cdot L^b$, with log transformation).

The external appearance of the gonads in the oldest individuals was observed for macroscopical determination of the stage of maturity. No macroscopic differences between males and females could be observed and consequently their data have been combined.

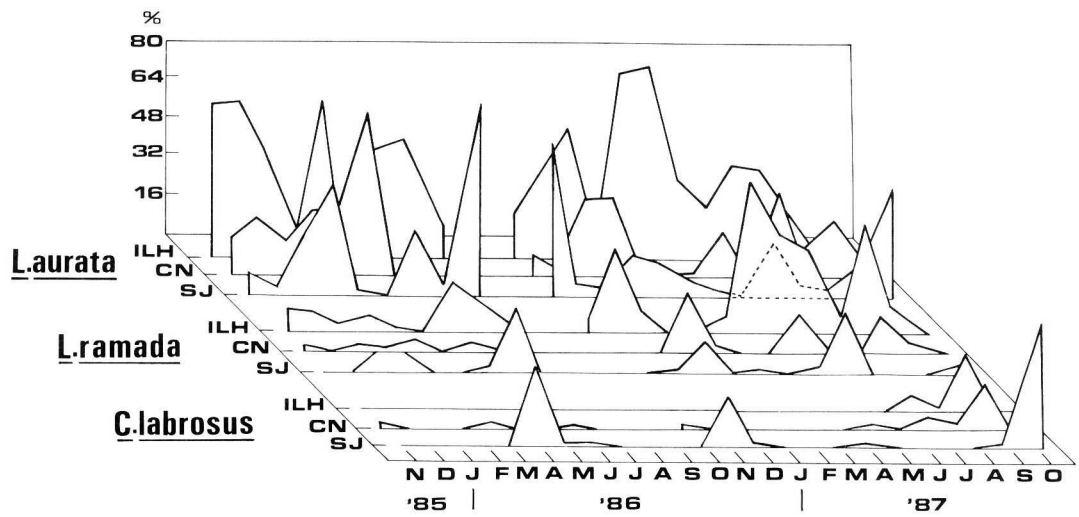

FIG. 3. — Percentual number of individuals of *L. aurata, L. ramada* and *C. labrosus* for each sampling period and for each sampling zones in Ria de Aveiro. (Abbreviations: ILH - Ilhavo; CN - Costa Nova; SJ - S. Jacinto).

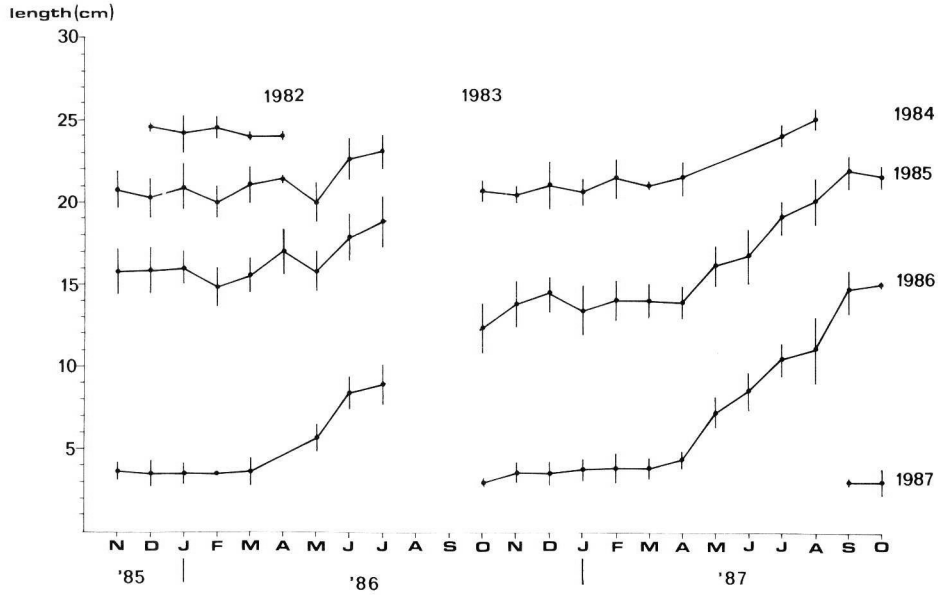

FIG. 4. — Monthly mean length for different year classes of *L. aurata* from Ria de Aveiro. Vertical lines indicate standard deviations. Year classes are given along the abscissa.

RESULTS

Temperature and salinity

Figure 2 shows both the mean temperature and the mean salinity of lagoon surface water taken monthly. On one hand the mean temperature followed a seasonal cycle ranging from 10° C in January 1987 to 20° C in July 1987. On the other hand there were large seasonal variations in salinity, from about 8.5 % in January 1986 to 18.5 % in July 1986.

Species and their abundance

Figure 3 shows the percent number of individuals of the species in each sampling zone. Because only one specimen of *M. cephalus* was found it was not included in these abundance distributions. *L. aurata* was normally dominant throughout the year. In contrast, *C. labrosus* was the least common. The oscillating abundances of species do not suggest any relationship neither between catch and temperature nor between catch and salinity.

Seasonal occurrence and growth of the species

L. aurata. Age determinations enabled the construction of growth curve throughout the monthly mean lenght (Fig. 4). These length distributions show the 0+ group golden grey mullets were first caught in September at a total length of 3 cm and the absence of individuals over age 4+ years. No detectable increase in length occurred at any age between December and March. Major growth (about 73 %) occurred during the first three years of life. In the following years the fish increased about 27 %. The length/age relationship described by von Bertalanffy's equation was: $Lt = 68.5(1 - e^{-0.11(t+0.51)})$. The weight/length equation calculated was: $\log W = -1.938 + 2.929 \log L$ ($r = 0.998$). Youngs of the year were first caught with a mean weight of 0.5 g. Maximum weight of the fish gathered for this study was 208.7 g.

Table 2 shows the percent occurrence of each age group. The fish of age group 1+ were the most abundant (67.8 %).

TABLE 2. — Percent occurrence at each year of life of *L. aurata*, *L. ramada* and *C. labrosus* from Ria de Aveiro.

	Age (years)				
	0+	1+	2+	3+	4+
L. aurata	3.4	67.8	23.7	4.3	.8
L. ramada	.9	69.5	27.2	1.8	.6
C. labrosus	56.0	44.0			

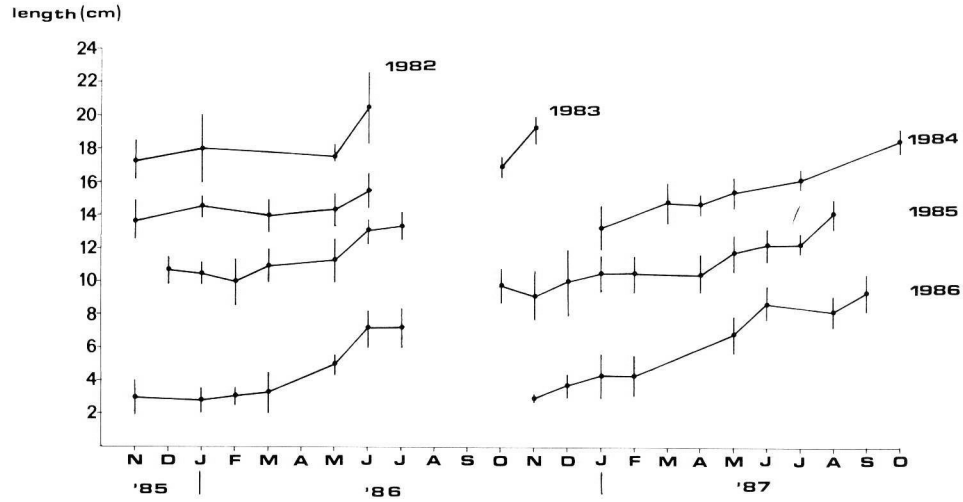

FIG. 5. — Monthly mean length for different year classes of *L. ramada* from Ria de Aveiro. Vertical lines indicate standard deviations. Year classes are given along the abscissa.

L. ramada. Figure 5 shows the growth curve throughout the monthly mean length based on age determination. This growth curve shows the younger fish entered the catches at a mean total length of 3 cm (range 2-4) in November and grew slowly until spring. Growth then increased until winter when the fish had reached a mean length of about 10 cm (range 8-12). This last season corresponds to a relatively slow growth in winter after which another period of rapid growth brings the mean length to about 15 cm in October. During the first three years of life the fish increased about 64 % in length and about 36 % during the following years. The von Bertalanffy's growth equation determined from the length/age data was: $Lt = 65.8(1 - e^{-0.08(t+0.6)})$.

The relationship between weight and length is expressed as: $\log W = -1.978 + 2.937 \log L$ ($r = 0.998$). The mean weight of juveniles first appearing in November was 0.4 g. Before emigration to the sea, older fish were about 83 g in weight.

The percent of occurrence of each age group is shown in table 2. About 97 % of the fish belonged to age groups 1+ and 2+. So, youngs of the year as well as individuals over age 2+ years were infrequent.

C. labrosus. During the first sampling period (November 1985-October 1986) only individuals of the year were captured. Larger individuals were caught only in the second year. Moreover, the fish of age group 0+ were always the most abundant. Juveniles started migration from the lagoon to the sea in October producing a decrease in the total biomass of the species in the lagoon. Then they are 1+ year old. Older individuals were rare.

The length-at-age data are shown in figure 6. The first occurrence of the juveniles was in October at a mean total length of 3.5 cm (mean weight 0.8 g). The fish grew slowly through autumn and winter and by May a mean length of 10 cm had been attained. Then followed a period of rapid growth in May-October which brought the mean length to about 20 cm (mean weight about 75.5 g).

Sexual maturity

No mature or maturing gonads were found. Both, the ovaries and testes were colourless and thread-like in appearance.

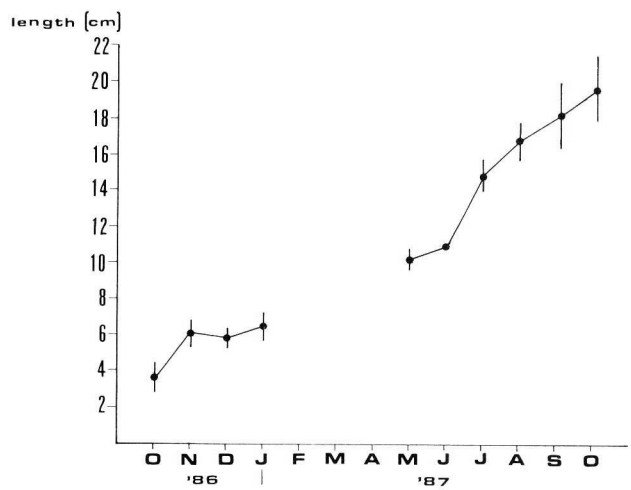

FIG. 6. — Monthly mean length for the year classes 1986 of *C. labrosus* from Ria de Aveiro. Vertical lines indicate standard deviations.

DISCUSSION

They grey mullets formed transient populations of fish whose numbers were regulated by the immigration of 0+ group fish from the sea and the emigration of older groups. All grey mullets caught were immature which suggests that the species do not breed in the lagoon and the emigrants will remain in the sea at least 1 year before spawning.

The species *L. aurata* was the most abundant and widespread of the four species found in the lagoon. *M. cephalus* was a rare species. The abundance data indicate that as a habitat the lagoon was most suitable for *L. aurata*. This could be due to the intrinsic abiotic and biotic characteristics of the area, or simply due to its accessibility to planktonic stages moving inshore from what are almost certainly offshore spawning areas. This latter point is impossible to evaluate, the first is probably related to the more "marine" features of this species.

L. ramada has been recognized as moving further into freshwater regions of estuaries (PERLMUTER *et al.*, 1957; HICKLING, 1970). The scarcity in the samples of 0+ group individuals, however, indicates that the habitat in Ria de Aveiro may provide a less favourable environment for this species since the young of many marine fish are known to penetrate areas peripheral to the normal range of adults and in which survival is often marginal. These two species, so similar in morphology and superficially similar in their ecology, as well as *C. labrosus*, exhibit differences in relative abundance. What factors in the environment or physiology of these organisms, however, control or limit their relative abundance and local distribution still need to be determined.

The juveniles of *L. aurata* were the first entering the catches when they 3 cm total length and were likely to be the only ones in September (*C. labrosus* and *L. ramada* first entered the catches in October and November, respectively). This late summer-autumn recruitment pattern and size of *L. aurata* juveniles agrees with the data available on the migratory season of other authors (THONG, 1969; REAY, 1987; CHERVINSKI, 1975), if one thinks on the clinal variation of the mean sea water temperature, increasing from waters around England to those of the Mediterranean. Moreover, the recruitment of that species *(a)* on the Atlantic Brittany coast takes place in July and by September some fish have grown 58 mm (THONG, 1969), *(b)* on the English coast (Langstone Harbour) the first juveniles were usually taken in March and April when the fish are 20-35 mm total length (REAY, 1987) and *(c)* on the Mediterranean coast as early as January-April (CHERVINSKI, 1975).

No direct data on spawning season have been obtained from the present study but the first occurrence of the juveniles suggests that the spring spawning established for populations of *C. labrosus* (KENNEDY & FITZMAURICE, 1969; HICKLING, 1970) would apply to the Ria de Aveiro lagoon. Because of the uncertainties about true spawning season, the use of 1st January birth-date did result in a 0+ group phase (from spawning to the initial 1st January) being less than 12 months in duration.

The grey mullets grew in length during the spring and summer, followed by a period of slow growth for the next 5 or 6 months. A comparison of the growth curves throughout the monthly mean length and temperatures shows that most of the annual growth took place at a time when temperature was highest. Most of the growth occurred above 14° C. KENNEDY and FITZMAURICE (1969) have related the cessation of growth, in mullets kept over the winter in an aquarium tank in an unheated laboratory, to a reduced rate of metabolism caused by low temperatures, as well as to a partial winter fast. Moreover, juvenile at water temperatures of above 10° C fed actively; at water temperatures of 8-9° C they fed only spasmodically and sparingly; at temperatures below 8° C they ceased feeding and became inactive. In contrast, there is no appreciable relation between the rate of increase of length and salinity. DE SILVA and PERERA (1976) also found no appreciable relation between the rate of increase of length and the salinity in the natural environment.

TABLE 3. — Mean lengths (cm) of grey mullets derived from von Bertalanffy's equation (*see* text) and mean lengths of *D. labrax*, *A. anguila*, *P. flesus*, and *S. senegalensis* from Ria de Aveiro.

	Age (years)				
	0+	1+	2+	3+	4+
L. aurata (This study)	3.7	10.5	16.5	21.9	26.8
L. ramada (This study)	3.1	7.9	12.4	16.5	20.3
D. labrax (GORDO, 1989)	11.2	16.6	21.3		
A. anguila (Gordo, pers. com)	9.5	17.2	23.3	29.5	35.1
P. flesus (Unpublished data)	9.3	19.5	23.6	27.5	34.2
S. senegalensis (Unpublished data)	12.	17.8	22.7	25.5	28.9

The scarcity of both *M. cephalus* and *C. labrosus* eliminates their possible use for culture in salt pans. The remaining species were available in quantity. The results of this study, however, indicate that although they can be stocked in the salt pans, culturing them as the main crop will not be feasible. Their growth rates do not compare favourably with those of the other fish (*Dicentrarchus labrax* (Linnaeus, 1758); *Anguilla anguilla* (Linnaeus, 1758); *Platichthys flesus* (Linnaeus, 1758) and *Solea senegalensis* (Kaup, 1858) occurring in the Ria de Aveiro (Table 3) and suggest that the fish would have to spend a long time in the salt pans before commercial lengths were reached.

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REFERENCES

ARRUDA, L. M., J. P. ANDRADE & M. M. CUNHA. — 1988. Abundance, diversity, and community structure of the fish population in the Ria de Aveiro (Portugal). *Oceanologica Acta,* 11, 3: 235-240.

BEN-TUVIA, A. — 1986. Mugilidae. In: Fishes of the North-eastern Atlantic and the Mediterranean. Ed. P. J. P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen, E. Tortonese, Unesco: 1197-1204.

CHERVINSKI, J. — 1975a. Experimental raising of golden grey mullet (*Liza aurata* (Risso)) in saltwater ponds. *Aquaculture,* 5: 91-98.

— 1975b. *Liza aurata* (Risso) (Pisces, Mugilidae) and its adaptability to various saline conditions. *Aquaculture,* 5: 110.

— 1976. Growth of the golden grey mullet (*Liza aurata* (Risso)) in saltwater ponds during 1974. *Aquaculture,* 7: 51-57.

DE SILVA, S. S. & P. A. B. PERERA. — 1976. Studies on the young grey mullet, *Mugil cephalus* L. I. Effects of salinity on food intake, growth and food conversion. *Aquaculture,* 7: 327-338.

GORDO, L. S. — 1989. Age, growth and sexuality of sea bass, *Dicentrarchus labrax* (Linnaeus, 1758) (Perciformes, Moronidae) from Aveiro lagoon, Portugal. Sci. mar., 53 (1): 121-126.

HALL, A. — 1980. Water quality problems in Ria de Aveiro. Preliminary assessment. *Seminar on actual problems of Oceanography in Portugal,* Lisbon, 20-21 November: 159-169.

HALL, A. & A. DUARTE. — 1984. Aquacultura na Ria de Aveiro. *Pesca e Navegação,* 6: 8-13.

HICKLING, C. F. — 1970. A contribution to the natural history of the English grey mullets [Pisces, *Mugilidae*]. *Journal of the Marine Biological Association of the United Kingdom,* 50: 609-633.

KENNEDY, M. & P. FITZMAURICE. — 1969. Age and growth of thicklipped grey mullet *Crenimugil labrosus* in Irish waters. *Journal of the Marine Biological Association of the United Kingdom,* 49: 683-699.

PERLMUTER, A., L. BOGARD & J. PRUGININ. — 1957. Use of the estuarine and sea fish of the family Mugilidae (grey mullets) for pond culture in Israel. *Proceedings and Technical Papers of the General Fisheries Council of the Mediterranean,* 4: 289-304.

QUIGNARD, J. P. & H. FARRUGIO. — 1981. Age and growth of grey mullet. *Aquaculture of Grey Mullets.* Ed. O. H. Oren. International Biological Programme 26. Cambridge University Press: 155-184.

REAY, P. J. — 1987. A British population o fthe grey mullets, *Liza aurata* (Teleostei; Mugilidae). *Journal of the Marine Biological Association of the United Kingdom,* 67: 1-10.

SPARRE, P. — 1987. Computer programs for fish stock assessment. Length — based fish stock assessment for Apple II computers. *FAO, Fisheries Technical Papers* (101), suppl. 2: 1-218.

TANG, Y. A. — 1975. Collection, handling and distribution of grey mullet fingerlings in Taiwan. *Aquaculture,* 5: 81-84.

THONG, L. H. — 1969. Contribution à l'étude de la biologie des Mugilides (Poisson, Téléostéens) des côtes du Massif Armoricain. *Travaux de la Faculté des Sciences, Université de Rennes,* (sér. Oceanographie Biologique), 2: 55-182.

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