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Fish biology

GROWTH CHARACTERISTICS OF GILT SARDINE (*SARDINELLA AURITA* VAL., 1847) FROM SENEGAL

CHARAKTERYSTYKA WZROSTU AURITY (*SARDINELLA AURITA* VAL., 1847) Z REJONU SENEGALU

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The author presents his results on growth rate of gilt sardine (*Sardinella aurita* Val., 1847) obtained from scales back readings and compares them with results arrived at by other workers in order to select the most appropriate growth characteristics of the species.

INTRODUCTION

Gilt sardine *(Sardinella aurita* Val., 1847) is a species very common along the African Atlantic coasts from West Sahara to Angola; the species occurs in the Mediterranean Sea as well. Within its entire range the species forms a number of local stocks differing one from another in certain biological traits.

Because of that, and also considering the fact of the species being of a significant importance to commercial pelagic fisheries, the biology of gilt sardine, its growth characteristics in particular, has attracted the attention of numerous workers as evidenced by a large body of papers on the subject. Among the others there were Ananiades (1951) and El Maghreby et al. (1970) who focused their attention on the species growth in the Mediterranean, and Gheno (1968, 1975) and Shcherbich (1980) who conducted similar studies on the Angolan shelf stock. Information on growth of the Mauritanian-Senegalese

gilt sardine stock are to be found in reports by Pham Thuoc and Szypuła (1973), Biester and Bui-Dinh-Chung (1975), Szypuła (1979), and Boely et al. (1980).

It needs to be emphasised that the results presented by the above-mentioned authors show significant discrepancies in some instances. Some of the variation may be accounted for by natural conditions, as is the case of a slower growth rate and smaller size of the Mediterranean gilt sardine. Other differences, however, result clearly from different methodological approach and interpretation of results.

In view of the importance of the knowledge on the species individual growth, leading to determination of other parameters of the stock and eventually to a more precise resource assessment, the author has thought it purposeful to conduct a study results of which might aid in a final formulation of growth characteristics of gilt sardine belonging to the stock in question.

MATERIALS AND METHODS

Materials for the present study were collected during cruises of the following B-29 trawlers:

1. MT "Kantar" operating from July through September 1978 in the area between Dakar and Cape Roxo at the 16–30 m depth range;
2. MT "Kanaryjka" operating from March through August 1980 over the whole Senegalese shelf at the 16–120 m depth range. The vessels were fishing with pelagic trawls provided with 40 mm mesh size codends.

The following procedures were adopted when collecting and working out the materials:

– the fork length (LF) was considered when measuring fish length to the nearest cm below;

scales for age reading were taken from the lateral line anteriorly to the dorsal fin;

age readings and measurements were performed on the oral margin of a scale placed under a Zeiss projector microscope provided with a measuring device.

A total of 919 individuals measuring 13–32 cm were examined.

It should be stressed that gilt sardine scales, in spite of their large size, are difficult to read because of their numerous additional rings. Hence it was necessary to compare age readings made on several scales taken from the same specimen. Insofar as age readings of 1- and 2-yr-old individuals presented no particular difficulty, older fishes yielded a relatively high percentage (about 20%) of illegible scales.

The photograph plates present the principles followed when interpreting the readings and determining annual increments.

Growth rate was determined from back readings using the Rosa Lee formula:

$$l_n = c + \frac{n}{R}(L-c)$$

where: c = a correction factor
L = fish length
R = scale radius
l_n = fish length at the age n
r_n = scale radius at the age n

Theoretical growth parameters were determined from the von Bertalanffy equation.

LENGTH (LF) – SCALE RADIUS RELATIONSHIP IN GILT SARDINE

The relationship was determined from measurements of scales taken from individuals measuring 16–31 cm. The results are presented in Fig. 1 points corresponding to partial means. Their pattern shows the relationship between the gilt sardine length (L) and scale radius (R) to be expressed by a straight line. Based on the coefficients computed, the expression takes the form of

$$L = 4.9209\,R - 2.042$$

A high determination coefficient (r^2 = 99.2%) points to an absolutely positive correlation between the variables studied.

In her studies, Szypuła (1979) obtained results necessitating the use of the Rosa Lee formula in age back-calculations; the data reported by Pham Thuoc and Szypuła (1973), who also studied the relationship, indicate to a direct relationship existing between the variables, hence their use of the Dahl-Lea formula.

It is thought that the differences in calculating procedures adopted by various authors are associated with their selection of a scale part on which to take measurements as well as with fish size and a particular part of the body from which scales were taken.

LENGTH GROWTH

Using the Rosa Lee formula the body length of fish in each age group was calculated from back readings separately for both sexes. The results are presented in Tables 1 and 2. When the lengths attained in various years of life by males and females of the same age groups are compared, the younger fishes are observed to exhibit larger size than the older ones. In the present case this apparent abnormality, known by ichthyologists as "the Rosa Lee phenomenon", is thought by many authors to have presumably resulted from the fastest-growing individuals being recruited at the earliest. As a consequence, they are caught at the earliest, too, while those individuals having a slower growth rate remain among the older fishes. It should be noted that data on the age group 8 are particularly different from the values typical of the remaining age groups. This fact results presumably from a low number of individuals examined.

The von Bertalanffy equation was used to present a theoretical description of the gilt sardine length growth; the equation parameters calculated from empirical data are as follows:

Table 1

Length growth rate of gilt sardine females as calculated from back readings (cm)

Age group	n	mean length (direct measurement)	back calculated length (LF)							
			l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8
I +	89	18.42	15.26							
II +	141	20.50	16.05	19.26						
III +	54	23.89	14.26	19.77	23.08					
IV +	42	26.10	14.58	19.84	23.26	25.69				
V +	52	28.06	13.59	18.91	22.85	25.67	27.55			
VI +	37	29.33	13.53	18.92	22.80	25.53	27.54	29.07		
VII +	15	30.67	14.50	18.12	21.99	24.82	27.22	29.08	30.27	
VIII +	4	31.25	12.62	18.39	22.00	24.64	27.04	28.85	30.05	31.13
	$\bar{x}$ mean		14.29	19.03	22.66	25.27	27.34	29.00	30.16	31.13
	S (standard deviation)		1.07	0.65	0.54	0.50	0.25	0.13	0.16	–
	V (variation coefficient)		0.08	0.37	0.03	0.02	0.01	0.01	0.01	–
	$l_n - l_{n-1}$		14.29	4.74	3.63	2.61	2.07	1.66	1.16	0.97
	Total		434	345	204	150	108	56	19	4

Table 2

Length growth rate of gilt sardine males as calculated from back readings (cm)

Age group	n	mean length (direct measurement)	Directly back calculated length (LF)							
			l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8
I +	65	18.26	16.75							
II +	150	20.46	14.17	19.21						
III +	34	23.32	13.89	19.20	22.48					
IV +	25	26.08	15.91	19.22	23.10	25.42				
V +	43	27.65	13.29	18.43	22.24	25.02	27.11			
VI +	34	29.50	13.23	18.27	22.22	25.06	27.22	28.63		
VII +	13	30.38	13.05	18.46	22.30	25.08	27.32	28.90	30.20	
VIII +	3	30.00	11.32	16.79	20.59	23.47	25.44	27.26	28.63	29.72
	$\bar{x}$ (mean)		14.01	18.51	22.15	24.81	26.77	28.26	29.41	29.72
	S (standard deviation)		1.68	0.87	0.83	0.77	0.89	0.87	1.11	–
	V (Variation coefficient)		0.13	0.05	0.04	0.03	0.04	0.04	0.05	–
	$l_n - l_{n-1}$		14.01	4.50	3.64	2.66	1.96	1.49	1.15	0.31
	Total		367	302	152	118	93	50	16	3

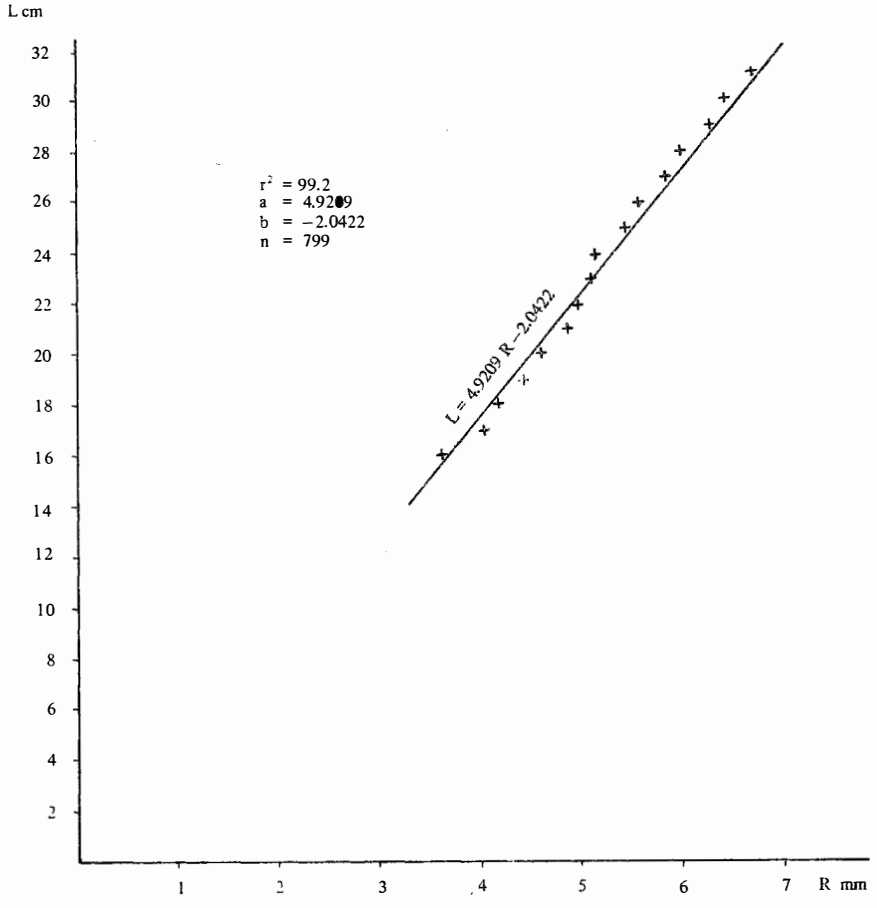

Fig. 1. Relationship between gilt sardine length (L.F) and scale radius

growth parameter	males	females	males+females
L_∞(mm)	320.2	339.8	331.5
t_o	−0.955	−0.991	−0.989
k	0.3026	0.2742	0.2832

Fig. 2 presents growth curves form males and females plotted according to the von Bertalanffy equation. Both the graphs and the values given in Tables 1 and 2 allow to observe the growth rate in the first three years to be similar in both sexes. Later, the male growth rate tends to decrease slightly.

When discussing the gilt sardine growth rate it should be mentioned that the highest annual increment is obtained during the first year. Increments in subsequent years decrease gradually and yet remain rather high over the whole life span; for instance, the annual increment in the seventh year amounts to 1 cm.

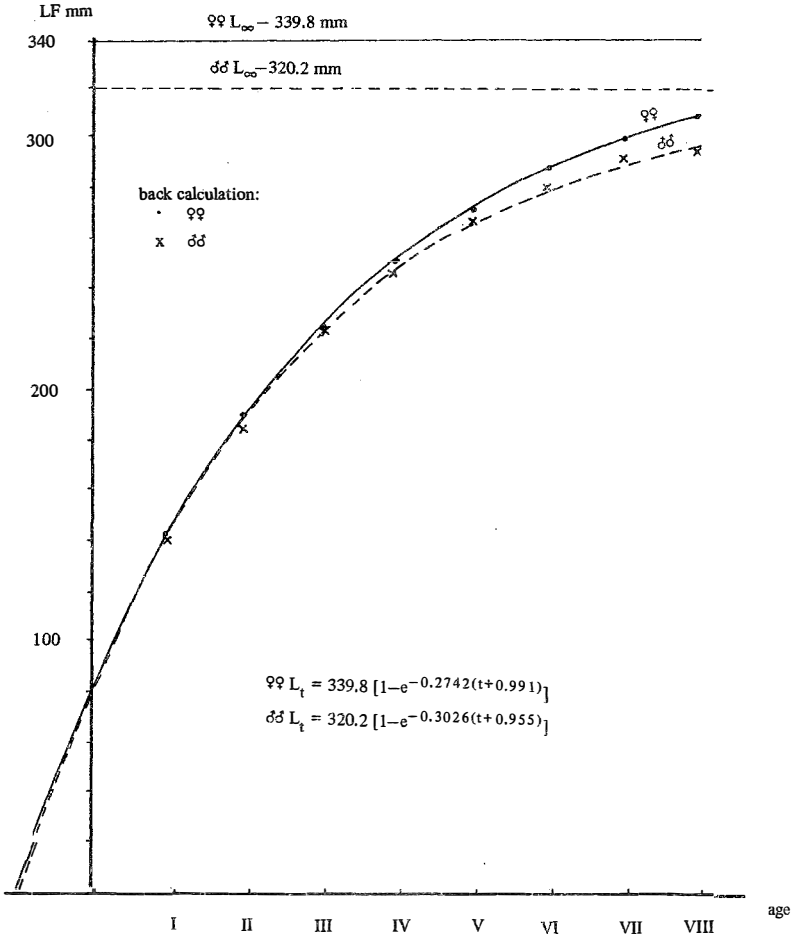

Fig. 2. Length growth curves of gilt sardine males and females according to Bertalanffy equation

Fig. 3 presents a growth curve plotted for both sexes jointly. The curve was compared to the results reported by other workers. The comparison indicates the gilt sardine growth characteristics presented to be very similar to those described by Pham-Thuoc and Szypuła (1973), Biester and Bui-Dinh-Chung (1975), and Szypuła (1979), while the results reported by Boely (1978) and Boely et al. (1980) are markedly different.

It should be stated that, as opposed to the results of the present author and others using mainly back readings from scales, Boely based his studies on observations of the species biology and interpretation of Petersen's curves, particularly with respect to the growth of young fishes; he treated the age readings made on a low number of scales in a rather complementary way. At the same time, it should be pointed out that Boely used the Dahl-Lea formula in his back calculations of growth rather than the Rosa Lee one, the latter being more appropriate to use on his materials. One can therefore contend that the

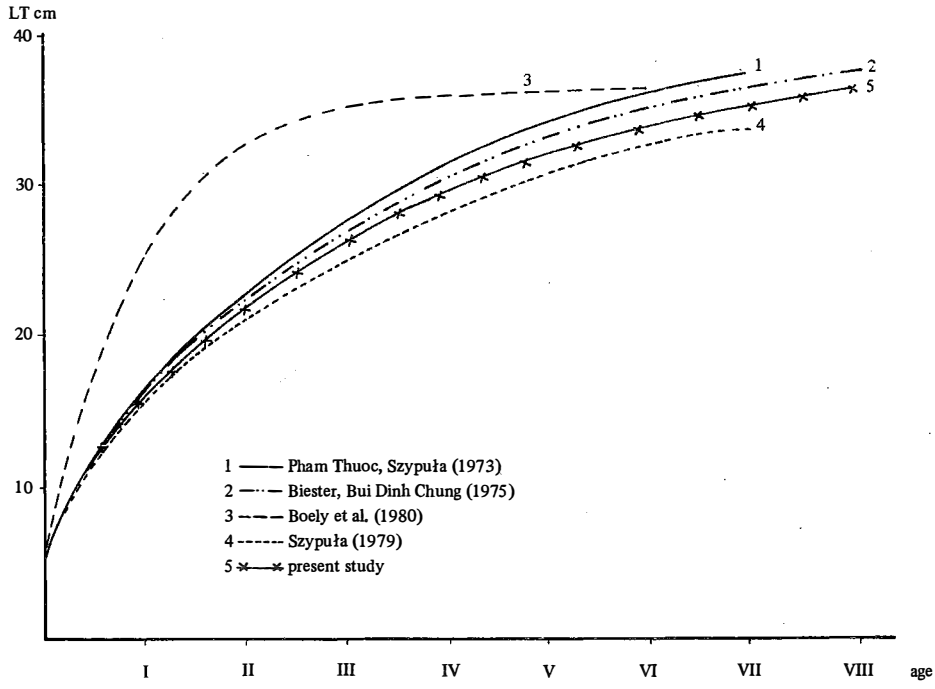

Fig. 3. Gilt sardine growth rate as calculated by various authors

different methodology outlined above is the main reason of the considerable discrepancy between the growth rate as determined by Boely on the one hand and the group of other authors on the other.

Boely's presentation of the gilt sardine growth can be questioned in view of the two important points raised below:

- Spawning on the Senegalese shelf within the first half of the year is generally accepted to play a major role in the gilt sardine reproduction. The bulk of recruitment is thus provided by that period. Should the sardine grow as assumed by Boely, 14–16 cm long individuals (6-mo-old according to Boely) would occur in masses in catches in the second half of the year, given the currently used codend mesh size. The length distribution analysis of catches of Senegalese purse-seiners and Polish trawlers over the last few years reveals a frequent occurrence of such individuals, but in the first half of the year only. They are absent in the second half in spite of the fact that – owing to reduced catches in that period – the fishes are sought also in shallower waters, typical habitats of the juveniles.

  It will be easy to explain the problem when the present author's notion on the gilt sardine growth is accepted. Teh group of young individuals occurring in the first half of the year is then regarded as the 1-yr-old ones.
- Boely et al. (1980) present their results of rearing young fish in aquaria. After the first 8 months the fishes attained lengths slightly exceeding 13 cm, as opposed to about

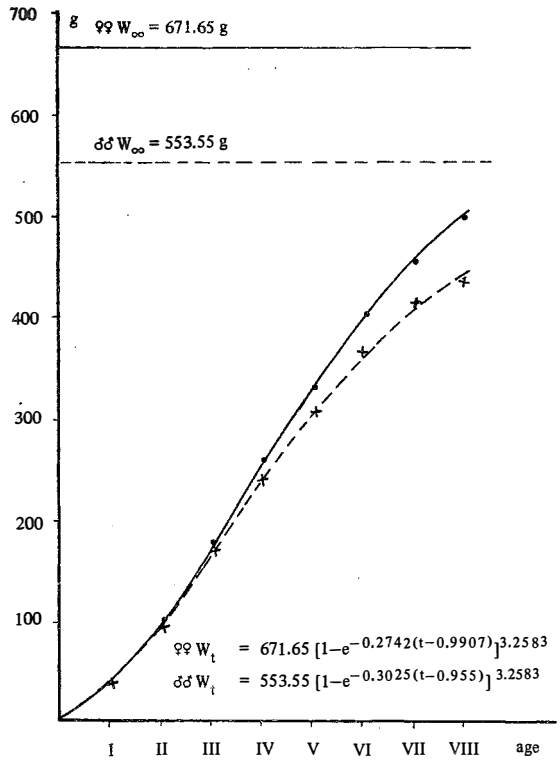

Fig. 4. Weight growth curves plotted for gilt sardine males and females according to modified von Bertalanffy equation (points determined from length-weight relationship)

18 cm predicted from a growth curve plotted by the authors. The 5 cm difference between observed and theoretical growth rates is significant enough to call for an explanation more convincing than a mere reference to inaccuracies in the studies.

In view of the above fact, it is particularly worth stressing that the growth of cultured fishes corresponds to the growth rate presented herein.

WEIGHT GROWTH

When discussing the fish weight growth, the relevant results of Boely (1978) are used. It should be mentioned that the results discussed are highly accurate as based on weighing fresh fish on shore.

Using the length-weight relationship developed by Boely (1978) for gilt sardines caught in the second quarter of 1969:

$$W = 0.3815 \cdot 10^{-5} L^{3.2583}$$

and the species length growth rate determined by the present author, a theoretical weight growth calculated separately for both sexes according to the modified von Bertalanffy equation is presented in Fig. 4.

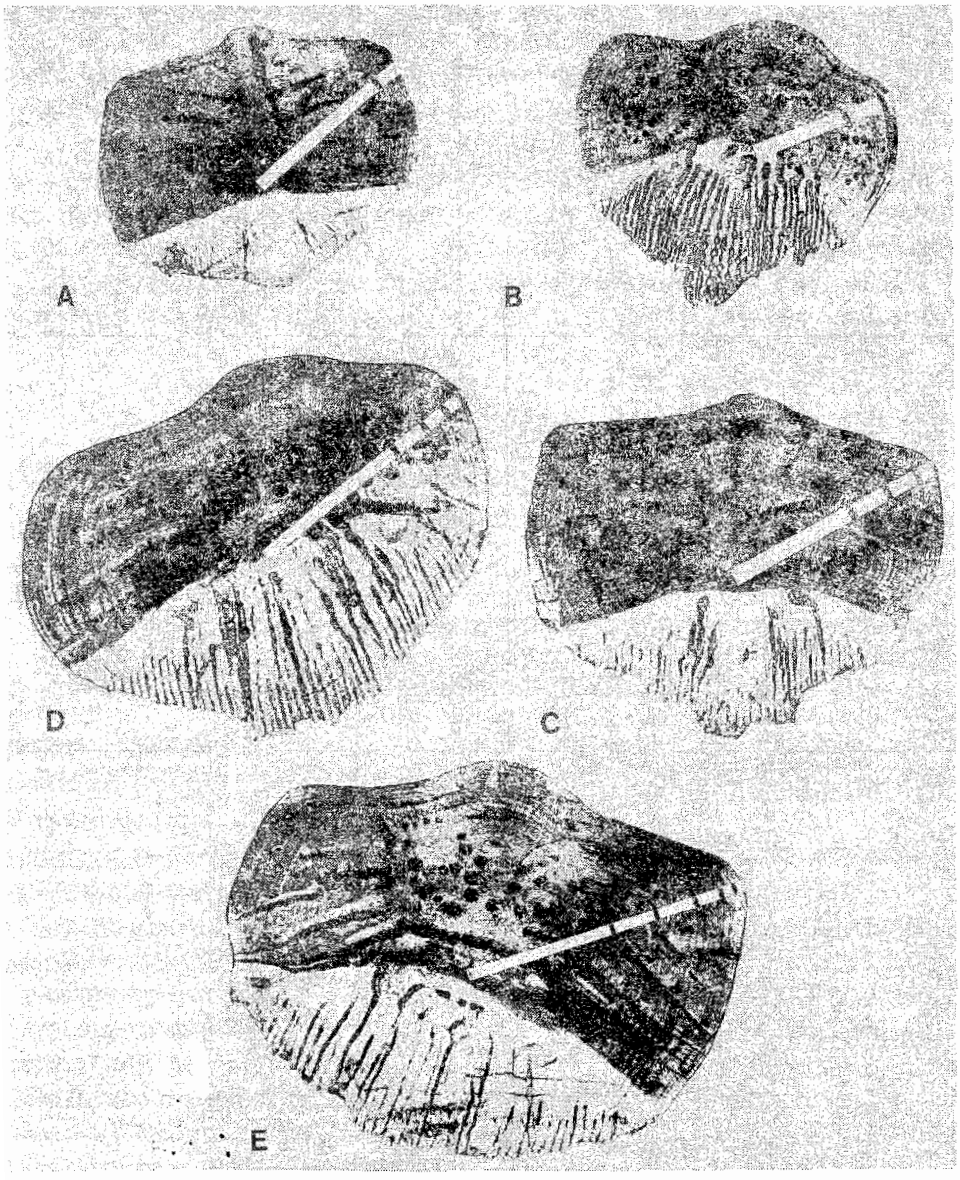

Fig. 5. A. Gilt sardine scale at the age 1+ (LF = 18 cm), B. Gilt sardine scale at the age 2+ (LF = 23 cm). C. Gilt sardine scale at the age 3+ (LF = 24 cm). D. Gilt sardine scale at the age 4 (LF = 27 cm). E. Gilt sardine scale at the age 5+ (LF = 27 cm)

Phot. M. Wutke

As can be seen, the gilt sardine weight growth proceeds in a typical manner: following an initial strongly accelerated growth, older individuals show a growth retardation. At the same time, noteworthy is the fact of a slower growth of males from their third year of life on. The characteristics of the weight growth presented is similar to that described by Szypuła (1979), a certain difference in the value of W_∞ (489 g for both sexes in the paper referred to and 620 g in the present study) being observed.

Although it is not the author's intention to contend that his results are the final and only appropriate ones, their logical relation to the available recruitment data, i.e., a contribution of young fishes to catches and growth of cultured juveniles, should be pointed out. Noteworthy is also the fact that the gilt sardine growth characteristics presented in this paper resembles the results obtained by most authors.

The above facts allow to suggest that any future consideration on stock assessment should assume a slower and more uniform growth of the species under study. This suggestion, however, merits a confirmation by way of detailed studies on juveniles (age groups 0 and 1) development to be carried out by tagging and observations of cultures.

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M. Krzeptowski

CHARAKTERYSTYKA WZROSTU AURITY (*Sardinella aurita* Val. 1847) Z REJONU SENEGALU

STRESZCZENIE

Tempo wzrostu aurity (*Sardinella aurita* Val.) mimo, iż jest ona jednym z ważniejszych dla rybołówstwa gatunków ryb pelagicznych w rejonie NW Afryki, nie zostało do chwili obecnej określone w sposób jednoznaczny.

Autor dokonał odczytów wstecznych z łusek i stwierdził, iż uzyskane wyniki wiążą się w sposób logiczny z dostępnymi informacjami na temat okresu zasadniczego tarła aurity i pojawiania się jej młodzieży w połowach oraz z danymi dotyczącymi hodowli młodych ryb w zbiornikach.

Przytoczone rezultaty badań sugerują, iż w pracach podejmujących problematykę oceny wielkości i stanu zasobów należałoby przyjąć koncepcję wolniejszego i bardziej równomiernego wzrostu omawianego gatunku.

М. Кржептовски

ХАРАКТЕРИСТИКА РОСТА КРУГЛОЙ САРДИНЫ (SARDINELLA AURITA VAL.1847) ИЗ РАЙОНА СЕНЕГАЛА

Р е з ю м е

До настоящего времени нет однозначного определения темпа роста круглой сардины (Sardinella aurita Val) хотя этот объект является одним из важных для рыболовства видов пелагических рыб в районе Северо-Запада Африки. Автор провел возвратные расчисления из чешуи и нашел, что полученные результаты можно логично связать с известными данными касающимися периода основного нереста круглой сардины и появления ее молодежи в уловах, а также с данными о выращивании молодежи. Результаты исследований дают основание предполагать, что в работах касающихся проблематики оценки величины и состояния запасов надо принять концепцию более медленного и равномерного роста рыб этого вида.

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