

# AGE AND GROWTH OF *TRACHURUS PICTURATUS* (BOWDICH, 1825) (TELEOSTEI: CARANGIDAE) FROM THE AZORES

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## ARQUIPÉLAGO



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From late 1983 to early 1987, 2530 *Trachurus picturatus* were sampled from captures around Faial and Pico Islands (belonging to the Central Group of the Azorean Archipelago). Biological parameters were taken using either fresh or frozen fish. Students' *t* test was applied to compare the slopes of the obtained weight-length regressions, leading to the conclusion that the two samples were significantly different for a 95% confidence limit. Thus parameters obtained with frozen fish were discarded. Weight-length regression obtained was  $W_t(g) = 0.00819 \times L_f^{3.11}$  (cm). Total length-fork length regression was  $L_t(cm) = -0.447 + 1.137 L_f$  (cm). The regressions between length, height and weight of left and right sagitta otoliths and the respective fork length were calculated. Further comparison between the obtained parameters lead to the conclusion that either could be used. Otolith sections were found to be the more reliable structures for age determination. An age-length key was established. The best fit to von Bertalanffy growth equation, using otolith age determination, was:  $L_\infty = 52.9$  cm;  $k = 0.20 \text{ year}^{-1}$ ;  $t_0 = -0.23$  year. Nevertheless a Gompertz growth curve may give a better fit.

ISIDRO, HELENA AZEVEDO 1990. Idade e crescimento de *Trachurus picturatus* (Bowdich, 1825) (Teleostei: Carangidae) dos Açores. - *Arquipélago. Ciências da Natureza* 8:45-54. Angra do Heroísmo, ISSN 0870-6581.

Desde fins de 1983 até 1987 efectuou-se a amostragem biológica de 2530 *Trachurus picturatus* provenientes de capturas efectuadas perto das Ilhas do Faial e Pico (ambas pertencentes ao Grupo Central do Arquipélago dos Açores). Os parâmetros biológicos foram obtidos em exemplares frescos e congelados. O teste *t* foi aplicado para comparar os declives das duas regressões comprimento-peso obtidas, permitindo concluir que as duas amostras eram significativamente diferentes para um limite de confiança de 95%. Daí que no presente trabalho os parâmetros obtidos com exemplares congelados tenham sido omitidos. A relação comprimento-peso obtida foi:  $W_t(g) = 0.00819 \times L_f^{3.11}$  (cm). A relação comprimento total-comprimento furcal foi:  $L_t(cm) = -0.447 + 1.137 L_f$  (cm). Também foram calculadas as relações entre o comprimento, a altura e o peso dos otólitos (*sagittae*) esquerdo e direito, e o comprimento furcal do respectivo indivíduo. A comparação das relações obtidas levou-nos a concluir que poderíamos utilizar quer o otólito esquerdo quer o direito. Para a determinação da idade concluiu-se que as secções dos otólitos eram as estruturas mais fáceis de observar. Foi estabelecida uma chave comprimento-idade. A melhor estimativa para a equação de crescimento de von Bertalanffy, determinando a idade através de otólitos foi:  $L_\infty = 52.9$  cm;  $k = 0.20 \text{ ano}^{-1}$ ;  $t_0 = -0.23$  ano. Contudo a equação de crescimento de Gompertz talvez se ajuste melhor.

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## INTRODUCTION

### Azorean fishery

*Trachurus picturatus* (Bowdich, 1825) (Portuguese common names are "carapau negro", in mainland and "chicharro", in Azores and Madeira) is the most important of the small pelagic species caught in the Azores. Data available since 1969 show a variation of commercial landings of horse mackerel between 2 and 4 thousand metric tons a year. From 1980 to 1987 they represented 84,5 % of the small pelagics total landings (Figure 1), mostly captured in the Oriental Group of the Azorean Archipelago.

For the same period *T. picturatus* annual landings have been in the first place in total landings (metric tons) and in first or second places in commercial value (thousand escudos) within all marine commercial Azorean species (with exception of tunas).

Besides landing data one must also consider

the captures, not quantified, as live bait for tuna fishery, highly important for the Archipelago fishery industry.

Small immature individuals of *T. picturatus* are mostly captured near the islands coasts, with dipnet or purse seine, either by the artisanal fleet or by tuna boats, respectively. Larger fishes, over 2 or 3 years old, represent an accidental capture in a longline fishery directed towards blackspot seabream (*Pagellus bogaraveo*) and other demersal species, in deeper waters and near "fishing banks".

### Taxonomic position and distribution

There is no general agreement about the taxonomic position of Azorean horse mackerel.

Ocean scad (RYTOV & RAZUMOVSKAYA 1984), ocean mackerel or blue scad (HUREAU & MONOD 1979), and blue jack mackerel (SMITH-VANIZ 1986) are some common English

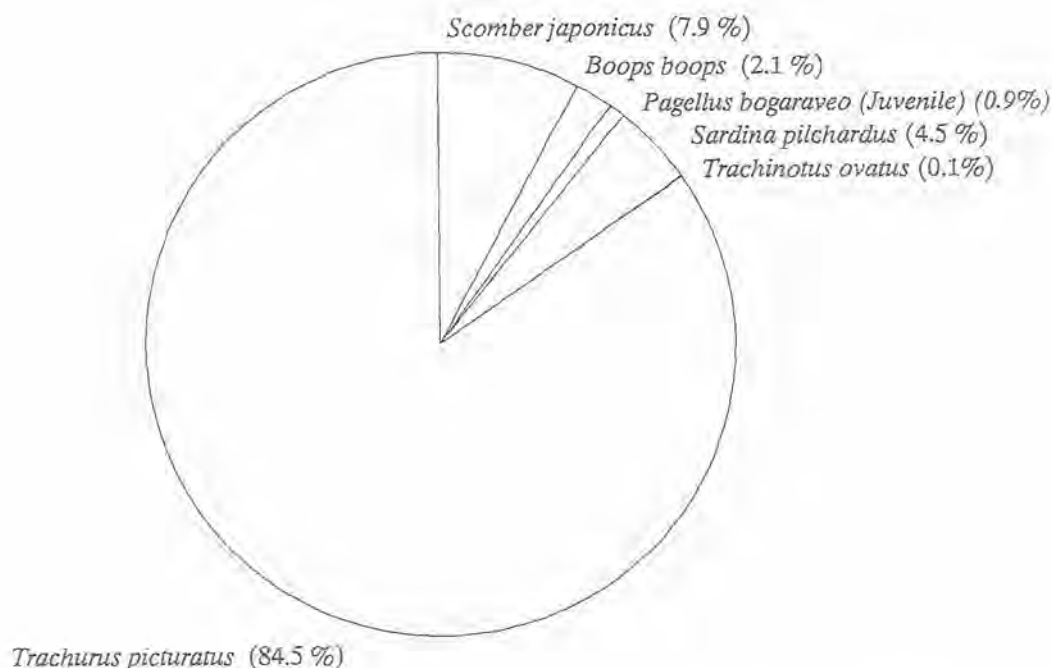


Fig. 1 - Weight percentage of small pelagics from commercial landings (Azores, 1980-87).

names for the species *Trachurus picturatus* (Bowdich, 1825), widely distributed along the Pacific coast of North and South America, in the Mediterranean and the Atlantic Ocean (Canaries, Azores and Madeira Archipelagos) (RYTOV & RAZUMOVSKAYA 1984) as well as in China (LETACONNOUX 1951).

ALEYEV (1957, cited in SHABONEYEV 1973) subdivides the genus *Trachurus* into several groups, according to morphological features, which are characteristic of the suitability of the individual forms of the genus *Trachurus* for a pelagic habitat. Thus, apart from *T. declivis*, *T. symmetricus*, *T. murphy* and *T. binghami*, he considers that the most oceanic and more complex from a systematic point of view is the species *T. picturatus*, and namely the sub-species *picturatus*.

SHABONEYEV, together with RYAZANTSEVA (1977) and with KOTLYAR (1979), refers that the oceanic horse mackerel, *Trachurus picturatus picturatus*, occurs in the Eastern Atlantic, along the coastal area of Western Europe, from the Bay of Biscay to the Azores and along the western coast of Africa to Mauritania, a typical form inhabiting the eastern part of the Central Atlantic. *Trachurus picturatus picturatus* is widely distributed not only on the continental shelf, but also far beyond its boundaries, in the regions of underwater elevations and seamounts, near the Canary Islands and the Azores (SHABONEYEV & KOTLYAR 1979).

Apart from the cited papers other authors may have used the name *Trachurus trachurus* when studying *T. picturatus*, which is unfortunate, as the biology of the two species might differ in many aspects (Helen Martins, personal communication). Thus one could possibly explain the lack of information about *T. picturatus*.

## MATERIAL AND METHODS

This species has been randomly sampled from commercial landings, especially in the Central Group of the Archipelago since mid 1979. The present paper refers to biological data collected

from specimens captured around Faial and Pico Islands (Central Group), between late 1983 and early 1987.

Biological sampling was made with either fresh ( $n = 2073$ ) or frozen ( $n = 457$ ) fish. Weights were taken to the nearest 0.1 g and length measurements to the centimeter below, corresponding to the length-class.

## Growth relations

Weight-length relationships  $W_t (g) = a \times L_t^b$  (cm) were determined using total weight ( $W_t$ ) against fork length ( $L_t$ ), as many specimens presented damaged caudal fins. The parameters have been determined using a computer statistical program TODOS (Eduardo Isidro, personal communication).

The linear relationship between total length ( $L_t$ ) and fork length ( $L_f$ ),  $L_t (cm) = a + b \times L_f (cm)$ , was determined for the available data.

Eventual differences between sexes have not been tested, based on the statement of SHABONEYEV & RYAZANTSEVA (1977) that sexual dimorphism does not exist in oceanic horse mackerel. Subsequently it was assumed that all data could be used without separating the sexes.

## Fresh and frozen samples

Freezing seems to have provoked an increase in weight and a decrease in length. Therefore, the slopes of the two logarithmic weight-length regressions were compared using the  $t$  test, as described by ZAR (1974), a simple method for testing the hypothesis about equality of two regression coefficients.

The statistic test is:

$$t = (b_1 - b_2) / S(b_1 - b_2)$$

$$\text{with } b = \sum xy / \sum x^2$$

where

$$S(b_1 - b_2) = \sqrt{(S^2_{y.x})_p / (\sum x^2)_1 + (S^2_{y.x})_p / (\sum x^2)_2}$$

and the pooled residual mean square is calculated as:

$$(S^2_{y.x})_p = [(\text{residual SS})_1 + (\text{residual SS})_2] / [(\text{residual DF})_1 + (\text{residual DF})_2]$$

$$\text{being residual SS} = \sum y^2 - (\sum xy)^2 / \sum x^2$$

The total degrees of freedom for this test is equal to the sum of the two residual degrees of freedom (DF):

$$DF = (n_1 - 2) + (n_2 - 2)$$

The subscripts 1 and 2 refer to the two regression lines being analyzed and  $n$  is the number of individuals in each sample.

The hypothesis  $H_0: \beta_1 = \beta_2$  was tested for  $\alpha = 0.05$ . The rejection of  $H_0$  implies the alternate hypothesis  $H_A: \beta_1 \neq \beta_2$ .

#### Scales and otoliths

Scales from different body zones were sampled. A preliminary analysis, however, showed that they did not seem to be reliable structures for age determination.

After extraction and cleaning with alcohol, sagitta otoliths were stored dry. A total of 803 pairs of whole and sectioned otoliths was used for age determination.

Both otoliths of the pair were weighed to the nearest 0.001 g and length and height measured to the nearest 0.01 mm, whenever otoliths were perfect. These measurements were related with the fork length of the respective individual.

Age reading of whole otoliths was done individually under reflected light against a dark background (opaque zones appear as white rings), with a binocular microscope (10 × 1.8). Immersion in different liquids was tested in order to find the best clarifying medium. Either water, 70° and 95° ethyl alcohol, xylene or glycerin (commercial or mixed with alcohol) were used.

Despite the difficulties in reading whole otoliths, previous immersion for 1 or 2 hours in a 70° alcoholic solution was better than water at giving clear evidence of the *annuli*. A more prolonged immersion gave worse results, either by turning them too hyaline (e.g. xylene) or too opaque (e.g. ethyl alcohol and glycerin).

CHRISTENSEN's technique (1964) for burning, breaking and reading otoliths was tried but did not improve the reading.

Whenever available, left otoliths were mounted in black polyester resin and sectioned, either transversely or longitudinally, according to Bedford's technique (WILLIAMS & BEDFORD

1974, BEDFORD 1977, 1983), with some local adaptations made by the author. This technique proved to be easy to handle. Otolith sections mounted between glass slides are easily stored and observed with transmitted light. Transverse sections gave good results for age reading, as opaque (summer rings) and hyaline (winter rings) zones became more clarified. Longitudinal sections were not readable.

Whenever difficulties occurred otolith sections were repeatedly read to ascertain age determination. Reading was easier in the lower part of the otolith (in relation to its position in the body). However, some difficulties concerning the identification of the first annual ring and false ones, especially in individuals over 3 years old, remained.

#### Von Bertalanffy growth equation

The von Bertalanffy growth curve was adjusted from otolith age determination. Parameters  $L_\infty$  and  $k$  were calculated using either the "Ford-Walford plot" or the "Allen method" (ALLEN 1985).  $t_0$  was calculated both using von Bertalanffy equation with the parameters obtained from the "Ford-Walford method", as the mean of the  $t_0$  values determined for each age-class, and by the "Allen method". The final von Bertalanffy growth equation was obtained by the "Allen method" giving the mean  $t_0$  value. All the parameters were obtained through the program TODOS (Eduardo Isidro, personal communication).

#### RESULTS

Fork length measurements in fresh fish varied between 11 and 42 cm (total length 47 cm). Helen Martins (personal communication) sampled a specimen with 54 cm total length, from Pico, in 1977. From mid 1979 to mid 1983, Westhaus-Ekau and Ekau (personal communication) sampled fishes between 17.5 and 42.5 cm fork length. ALBUQUERQUE (1954-56) and FOWLER (1936) referred a maximum total length around 60 cm.

Comparison between fresh and frozen samples  
Weight-length relationships obtained were:

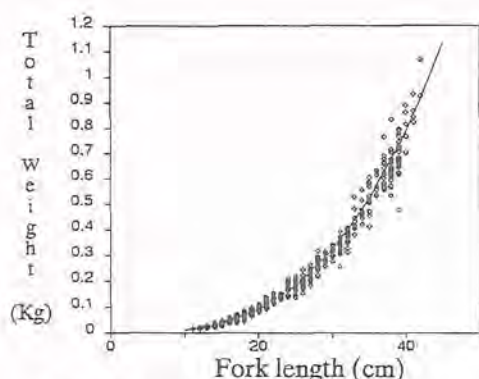


Fig. 2 - Weight-length relationship from fresh fish.  $W_t(g) = 0.00819 \times L_f^{3.11}$  (cm);  $n = 1934$ ;  $r^2 = 0.988$ .

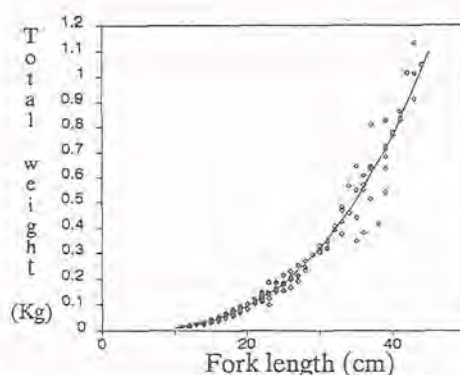


Fig. 3 - Weight-length relationship from frozen fish.  $W_t(g) = 0.00957 \times L_f^{3.06}$  (cm);  $n = 419$ ;  $r^2 = 0.988$ .

Table 1. t test for significance of regression coefficients (weight-length regressions using fresh and frozen samples).

SAMPLES	n	Res. DF	b	S (b <sub>1</sub> - b <sub>2</sub> )	t	p
(1) Fresh	1934	1932	3.0629	0.0176	2.7216	< 0.01 *
(2) Frozen	419	417	3.1108			

\* Null hypothesis rejected ( $p < 0.05$ )

$W_t(g) = 0.00819 \times L_f^{3.11}$  (cm);  $n = 1934$ ;  $r^2 = 0.988$  for fresh fish (Figure 2), and:

$W_t(g) = 0.00957 \times L_f^{3.06}$  (cm);  $n = 419$ ;  $r^2 = 0.988$  for frozen fish (Figure 3).

Comparison between the slopes of the logarithmic transformation of the relations (Table 1) showed that they are significantly different as  $p < 0.01$ .

For  $\alpha = 0.05$  we had to reject  $H_0 : \beta_1 = \beta_2$ , then  $H_A : \beta_1 \neq \beta_2$ .

Thus, for the present paper, only data obtained with fresh fish will be considered.

Total length-fork length relationship

The following relationship compares total

length ( $L_t$ ) with fork length ( $L_f$ ) (Figure 4):

$L_t(\text{cm}) = -0.447 + 1.137 \times L_f(\text{cm})$ ;  $n = 1880$ ;  $r^2 = 0.994$ .

Comparison between left and right otoliths

The t test was also applied to compare the regressions obtained from left and right otolith measurements (Table 2).

Null hypothesis was tested for all relations, for a significance level of 5%, and was not rejected, meaning that either could be used.

Regressions obtained between left otoliths ( $l_o$ ) measurements ( $L$ =length,  $H$ =height and  $W$ =weight) and fork length ( $L_f$ ) are:

$L_{l_o}(\text{mm}) = 1.759 + 0.224 \times L_f(\text{cm})$ ;  $n = 261$ ;  $r^2 = 0.964$  (Figure 5)

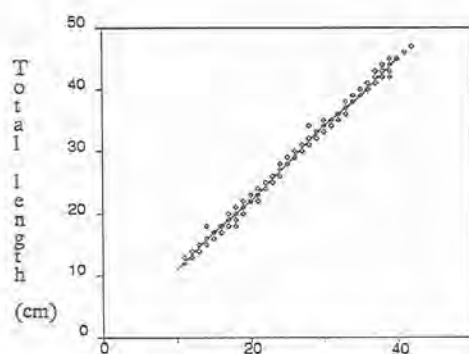


Fig. 4 - Relation between total length and fork length.  $L_t$  (cm) =  $-0.447 + 1.137 L_f$  (cm);  $n = 1880$ ;  $r^2 = 0.994$ .

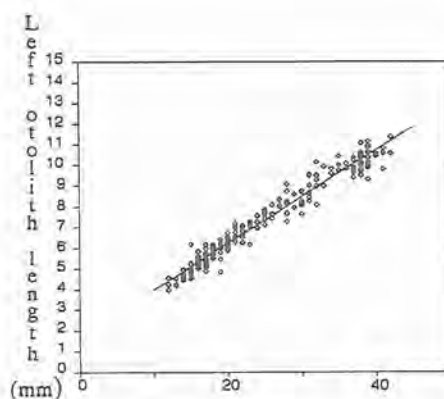


Fig. 5 - Relation between left otolith length and fork length.  $L_{lo}$  (mm) =  $1.759 + 0.224 L_f$  (cm);  $n = 261$ ;  $r^2 = 0.964$ .

$H_{lo}$  (mm) =  $1.180 + 0.089 \times L_f$  (cm);  $n = 261$ ;  
 $r^2 = 0.951$  (Figure 6)

$W_{lo}$  (g) =  $0.0000278 \times L_f^{2.072}$  (cm);  $n = 261$ ;  
 $r^2 = 0.962$  (Figure 7)

Age-length key by means of otoliths age reading

Age reading of whole otoliths proved to be quite impossible due to their opaqueness. Otolith

sections seemed to be more reliable structures for age determination in oceanic horse mackerel, although very thin sections did not present enough contrast between summer and winter zones, which are less differentiated in these temperate waters. Even with thick sections some opaque borders were very difficult to identify.

Table 2.  $t$  test for significance of regression coefficients (regressions between length, height and weight of left and right otoliths and the respective fork length).

OTOLITHS	n	Res. DF	b	S (b <sub>1</sub> - b <sub>2</sub> )	t	p
Length						
(1) left otolith	261	259	0.2239	0.0043	0.2558	> 0.50 *
(2) right otolith	257	255	0.2228			
Height						
(1) left otolith	261	259	0.0887	0.0029	0.7855	> 0.40 *
(2) right otolith	257	255	0.0910			
Weight						
(1) left otolith	261	259	-2.0715	0.0407	0.3538	> 0.50 *
(2) right otolith	271	269	-2.0571			

\* Null hypothesis not rejected ( $p > 0.05$ ).

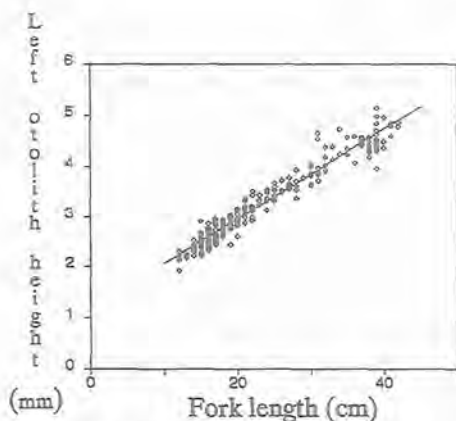


Fig. 6 - Relation between left otolith height and fork length.  $H_{lo} \text{ (mm)} = 1.180 + 0.089 L_f \text{ (cm)}$ ;  $n = 261$ ;  $r^2 = 0.951$ .

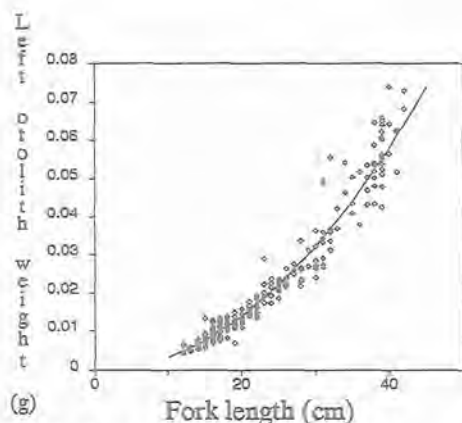


Fig. 7 - Relation between left otolith weight and fork length.  $W_{lo} \text{ (g)} = 0.0000278 L_f^{2.072} \text{ (cm)}$ ;  $n = 261$ ;  $r^2 = 0.962$ .

An age-length key and the mean fork length per age class are presented in Table 3.

#### Von Bertalanffy growth equation

Von Bertalanffy growth parameters were determined for both sexes together. Due to insufficient data ages 0-1 and 8-9 have been discarded for the calculations.

The values obtained using the "Ford-Walford plot" were  $L_{\infty} = 49.8 \text{ cm}$  and  $k = 0.23 \text{ year}^{-1}$ ;  $t_0 = -0.23 \text{ year}$ , was calculated as the mean of the  $t_0$  values obtained by the substitution of the above mentioned values in the von Bertalanffy equation.

Using "Allen method" the parameters obtained were  $L_{\infty} = 57.0 \text{ cm}$ ;  $k = 0.17 \text{ year}^{-1}$  and  $t_0 = -0.41 \text{ year}$ .

The "Allen method" was also applied to try a better adjustment of the von Bertalanffy growth equation by giving to  $t_0$  a certain value. Thus, for  $t_0 = -0.23$ ,  $L_{\infty} = 52.9 \text{ cm}$  and  $k = 0.20 \text{ year}^{-1}$ , which seemed to be the values that gave a better fit of von Bertalanffy growth curve (Figure 8).

#### DISCUSSION

The relationships obtained between otolith measurements and fork length will eventually allow the determination of a prey size from otoliths found in stomach contents (e.g. *T.*

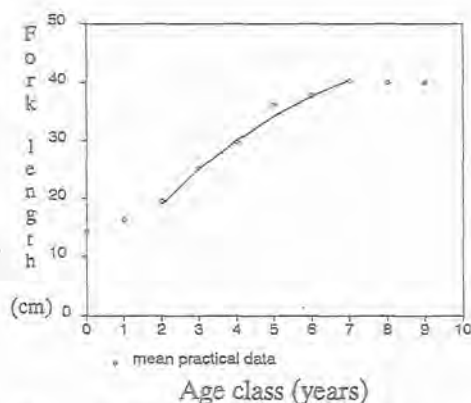


Figure 8. Von Bertalanffy growth equation for both sexes.  $L_f \text{ (cm)} = 52.9 (1 - e^{-0.20(t + 0.23)})$ ;  $n = 516$ .

*picturatus* is the most important food organism for *Loligo forbesi* in the Azores (MARTINS 1982)).

Age determination using otolith sections was found to be the best method for obtaining growth parameters. Nevertheless some difficulties remained concerning the identification of year rings in fishes 3 or 4 years and up. Maximum age given in previous studies is 11 years (POLONSKII 1967) which seems to be compatible with our results indicating a maximum of 9 years of age.

Estimates of  $L_{\infty} = 51.06 \text{ cm}$ ;  $k = 0.14 \text{ year}^{-1}$ ;

Table 3. Age-length key obtained from otoliths reading.

Fork length class (cm)	Age (year)									
	0	1	2	3	4	5	6	7	8	9
10										
11										
12	17	1								
13	11	4								
14	22	5								
15	19	20	4							
16	9	23	6							
17	11	22	13							
18	2	14	16							
19		5	16	2						
20		2	17	2						
21		2	9	4						
22			8	8						
23			1	5	1					
24			5	7	3					
25			4	10	3					
26			1	9	4					
27			1	6	4					
28			1	6	7					
29				3	3					
30				1	8		1			
31				2	8	2				
32				3	9	2	1			
33				1	5	3				
34					3	2	1			
35					1	7	1			
36					2	3	2			
37					1	5	9			
38						10	11	1		
39						5	13	3		
40						1	2		1	1
41						1	2	1		
42							1	1		
43								1		
44										
45										
46										
47										
48										
49										
50										
n	91	98	102	69	62	41	44	7	1	1
Mean L <sub>f</sub>	14.86	16.88	20.09	25.76	30.37	36.77	38.34	40.79	40.50	40.50

$t_0 = -1.58$  year, for total length, were calculated by Westhaus-Ekau and Ekau (personal communication) from a sample with a higher number of juveniles. Nevertheless our estimates, especially for  $k$ , seem to be more appropriate to this pelagic species as it seems to have a fast growth. For a better fit of our growth curve (Figure 8) more individuals under 15 cm and above 40 cm (fork length) should be sampled and otolith age determination should be reviewed. Otherwise Gompertz growth equation (RICKER 1980) should be applied.

#### ACKNOWLEDGEMENTS

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