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Title :

Estimation of Megrim (Lepidorhombus whiffiagonis) growth parameters, for males and females, from the I.C.E.S division VII : fitting to the V. BERTALANFFY model using, resampling techniques, as well as several adjustable central values (mean, median and mode length at age).

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Abstract :

Reading Megrim otoliths (Lepidorhombus whiffiagonis), caught in the I.C.E.S division VII, provided an estimate of the relationship between length and age for fishes, each sex separately.

The Von BERTALANFFY model (1938) has been widely employed to describe Megrim growth in length. In this, because of the small sample size (only 184 otoliths of males and 342 of females), and the difficulty in assessing the age of some fishes, data have been fit to the growth model using, resampling techniques (Bootstrap), as well as several central values of fitting (mean, median and principal mode length to age). The various results are presented and discussed.

Résumé :

Les lectures des otolithes de Cardines (Lepidorhombus whiffiagonis), capturées dans la division C.I.E.M VII, ont permi de déterminer la relation entre la longueur et l'âge des poissons de chaque sexe.

Le modèle de Von BERTALANFFY (1938) a été retenu pour décrire la croissance en longueur. Devant le faible nombre d'otolithes lus (184 pour les mâles et 342 pour les femelles) et la difficulté à estimer l'âge de certains poissons, les données obtenues ont été ajustées au modèle de croissance en utilisant, des techniques de rééchantillonnage (Bootstrap), et plusieurs valeurs centrales d'ajustement (moyenne, médiane et mode principal des distributions des longueurs aux âges). Les différents résultats sont présentés et discutés.

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1. Introduction.

The evaluation of the exploitation impact on Megrim stock (*Lepidorhombus whiffiagonis*) from the Celtic sea (area I.C.E.S VII) is demonstrated by a structural modelisation. The model used relies on catch length distribution (JONES 1974, 1979, 1981) and requires an estimation of the Von BERTALANFFY equation parameters. This estimation has been the object of many works (CONAN et al. (1981), RODRIGUEZ et al. (1985), AUBIN OTTENHEIMER (1986)). In view of the differences observed in the various results it has appeared essantial to re-estimate them.

Firstly the comparison of methods in the determination of winter rings of otolith growth-stop by Spanish teams (from el Instituto Espagnol de Oceanografia, I.E.O VIGO), and French teams (from l'Institut Français de Recherche pour l'Exploitation de la Mer, IFREMER LORIENT) lead to their harmonization. Secondly the utilisation of robust fit techniques (described by GROS et al.1987), rended necessary by the difficulty in estimating the age of some fishes and by the small sample size, permits us to optimize the estimation of growth parameters.

2. Material and methods.

2.1 Sample protocol.

With Megrim, otoliths are the hard component parts which best display evidences relative to the ecosystem condition changes (essentially temperature variations) undergone by fishes during their growth.

Otolith readings here proceed from two distinct samples :

- one taken between March and December 1987 at VIGO, on Megrim caught by the Spanish fleet in the I.C.E.S division VII.

- the other effected during the 1987 cruise on V/O CIROLANA in the same fishing area. This sample contained numerous young individuals.

Sample protocol consists of taking otoliths (with fixed allocation) from Megrim randomly selected . A maximum number of 10 otoliths is collected by one centimetre class length.

A total of 516 otoliths, 184 from males and 342 from females, were extracted. The length size-range covered by the sample is from 14 to 32 cm for males, and 16 to 49 cm for females.

2.2 Determination of Megrim age.

Considering the otoliths' opacity it is necessary to apply a preparatory technique before reading them. We used that which , from RODRIGUEZ et al.(1985), proved the most effective result : an immersion of the otoliths in alcohol during 24 hours.

Readings are effected in direct light and with a magnification of 20, simultaneously by two investigators. All readings are compared and discussed at the time of their observation.

Determination of Megrim age from otolith readings consists in counting numbers of hyaline zones present on it. By convention the birth-date is fixed at the first January. The age attributed to the fish whose otolith require n hyaline rings is :

- n years for the three first trimestrials.
- n-1 years for the fourth trimestrial if the edge of the otolith is hyaline (n otherwise).

2.3 Estimation of length growth parameters.

According to Von BERTALANFFY model, observed length L_{ij} from the j mth fish ($j = 1,2 \ldots n_i$) belonging to the age group i ($i = 1,2 \ldots I$) is defined by :

$$(1) \qquad L_{ij} = \theta_1 \cdot [1 - Exp(-\theta_2 (T_i - \theta_3))]$$

where :

θ_1, θ_2 and θ_3 are generally expressed L_∞, K and T_0.

If the column vector of the model parameters is escribed as θ, this is more simply written :

$$(2) \qquad L_{ij} = F(T_i , \theta)$$

where :

T_i is the age of the group i, of length L_i considered to be without error.

The estimation of the parameters (L_∞, K, T_o) from observed couples (L_i, T_i) is deduced from the utilisation of the maximum likelihood method. This method is prefered to the least square estimator when, as here, the model is not linear. It extraits the numerical value of the parameter sought which maximises the observed result density (GROS 1980). It calculates the estimators ($\hat{L}_\infty$, $\hat{K}$, $\hat{T}_o$) of (L_∞, K, T_o).These estimators are asymtopically normal, converging in probability and with a minimal variance.

The best optimality criterium for the calculation of L_∞, K and T_o is the minimisation of quadratic function of the differences between observed and forecast values (SMITH 1979). That of the least square is the most classical (KIMURA 1980) :

$$(3) \qquad S(\theta) = \sum_{i=1}^{I} \cdot \sum_{j=1}^{n_i} [L_{ij} - F(T_i,\theta)]^2$$

with the condition that the residuals are random variables, not correlated, normally distributed, with a nil expexted mean and with the same variances.

An optimisation of $\hat{L}_\infty$, $\hat{K}$,and $\hat{T}_o$ (reduction of the calculation time) is obtained by the criterium :

$$(4) \qquad S(\theta) = \sum_{i=1}^{I} W_i \cdot [\bar{L}_i - F(T_i,\theta)]^2$$

where :

$\bar{L}_i$ = mean length of the n_i individuals of age i.

W_i = weight associated to the i mth age group.

The approximate estimation $\hat{V}$ to the variance-covariance matrix is given by :

$$(5) \qquad \hat{V} = \sum_{i=1}^{I} W_i \, (\delta F_i / \delta\theta).(\delta F_i / \delta\theta)^T)^{-1} \cdot \sigma^2$$

where :

$\delta F_i/\delta\theta$ is evaluated to the optimum
$\sigma^2 = S\ (\hat{L}_\infty, \hat{K}\ , \hat{T}_0)/K-3$
K = number of age classes.
(T indicate the transposition)

The normal distribution of the residuals, a necessary condition to the validity of the equations (3) and (4) have, in practise, little chance of being verified. To palliate that, we have to resort to resampling techniques (Bootstrap, Jackknife described by GROS et al. 1987).

When otolith reading is difficult, the age determination of some individuals causes errors. So it is necessary to use an estimation procedure of the growth parameters which is the least sensitive possible to this pertubation. The estimation of $(L_\infty\ , K\ , T_0\ )$ by the optimization of a criterium like (4) relies on a minimization of the distance between model and one indicator of central densities tendency. If these extremities are deformed by age determination errors, it is advisable to define a robust position estimator. To this effect, the choice of the mean $\bar{L}_i$ is not adequate because this estimator is sensitive to the distributions extremities. So GROS et al. (1987) propose to use the median and criterium (4) becomes :

$$(6) \qquad S\ (\theta) = \sum_{i=1}^{I} W_i . [\ \bar{L}_{i,1/2} - F(T_i,\theta)\ ]^2$$

where :

$\bar{L}_{i,1/2}$ represents the semi truncated mean , which is called the median, of the age class i.

or the principal mode and criterium (4) becomes :

$$(7) \qquad S\ (\theta) = \sum_{i=1}^{I} W_i . [\ mode_i - F(T_i,\theta)\ ]^2$$

where :

$mode_i$ represents mode class of age i.

In these two cases covariance matrix estimator of the estimator is calculated by the Bootstrap algorithm (in GROS et al.1987).

2.4 Megrim data fitting to the V.BERTALANFFY growth model.

To fit the V.BERTALANFFY growth model to the data obtained on Megrim otolith reading, for both sexes, we used the software written by LAUREC (in GROS et al.1987). The non parametric Bootstrap resampling technique, described by EFRON (1979) is selected.

Three fitting values are tested : mean (criterium 4), median (criterium 6) and principal mode (criterium 7). Data are pre-traited by the software. In the calculation of the arithmetical means, the mean of each length class is attributed to each fish concerned. In the calculation of the median, the repartition function is discretisated because of the histogram creation. The value corresponding to a probability of 0.5, which defines the median, is obtained by a linear interpolation. In the calculation of the mode, the highest frequency class is at first identified. If it is a multiple, the arithmetical mean of the highest value and the lowest value is selected. If not, the only class corresponding to a strict maximum becoming evident, centre of the class concerned is considered on one side, the centre of the two next other classes on the other. The value obtained for mode estimation is the ponderal mean of these three values (the ponderation is made in function of the respective frequencies).

To take account of the age numbers observations and to give more weight to mean classes, fittings are done by the least squares ponderated by the sample size (W_i = ni). Ponderation by the variances is not possible here, because it leads to some aberration. In the Bootstrap sample systematically appear one or many cases where a variance σ_i^2 is very weak or nil (GROS et al.1987).

3. Results.

3.1 Age - length relationship.

Frequency histograms of length (in percentage) by age class for males and females have distinctly forms in function of the ages classes (Fig.1 to 3). Those of the intermediate classes 3-4-5 years are monomodal, the mode is generally well described. Those of superior classes (6 years for males, 6-7-8 -9 years for females) are multimodals, but have forms, very variable, often influenced by the small size of the observed sample.

3.2 Parameters of the VON BERTALANFFY equation.

For each of the fitting criteria various, central values of each age class predicted by the model and those of the growth parameters equation, with their variances, are presented, for both sexes, tables 3 to 6.

The growth parameter values selected are those which minimise the model residual variance. For the males it is obtained using the median of age class length distribution, for females the principal mode.

For Megrim the growth equation of the Von BERTALANFFY model is written :

- for males (Fig.4a) :

$$L_t = 43.67 \, [\, 1 - Exp^{- 0.14 \, (T - 1.76)} \,]$$

with :

L_∞ = 43.67 cm.
K = 0.14.
T_0 = -1.76.

- for females (Fig.4b) :

$$L_t = 65.20 \, [\, 1 - Exp^{- 0.09 \, (T - 1.87)} \,]$$

with :

L_∞ = 65.20 cm.
K = 0.09.
T_0 = -1.87

4. Discussion.

Further to the calculation method influence, differences between the three fitting central values (mean, median, principal mode) to a given age, have two origins. The first steming from the otolith reading difficulty from the oldest fishes (5 years and more). To the opacity of the otolith add the problem of distance diminution between the more peripherical winter stop-growth rings . The second coming from the effect that Megrim individual growth is not homogeneus.

Length distributions at ages, and more particularly their extremities, are therefore deformed by errors in estimating age. The use of the arithmetical mean (estimator which appears the most sensitive to the extremities distributions) like the central fitting value, appears here inadequate. In this case of the fitting of observed values after the read of Megrim males and females otoliths, median and principal mode have been respectively shown to be the best position estimators. The adequacy of one or other of these estimators to the growth model seems to proceed from the aspect of length distribution observed at each age for Megrim of both sexes. The results obtained are in reality consistent with the espectations and they aproximate those calculated by GROS et al.(1987) in the study of (Spisula ovata) and by MOGUEDET (1988) in the one of the estimations of those of Ling (Molva spp.).

The growth length parameters estimation of Megrim shows that growth depends on sex. Males reach a length inferior to that of females rate (respectively 44 cm and 65cm). However their growth rate is faster (K = 0.14 for males and K = 0.09 for females).

This growth difference as a function of sex is also observed in previous works (Tab.7). But these growth paramaters estimated, L_∞ and K, are sometimes distinct from ours. The divergence in the results is due to the reading and/or fitting methods which are different. What concerns the growth parameters relatives to females, it appears, except for the work of CONAN et al.(1981), that results obtained are nearest. Observed differences are probably only due to the fitting type used (backcalculation by RODRIGUEZ et al.(1985), likelihood maximum method with ponderation by the variance or the sample size by AUBIN OTTENHEIMER (1986)). In the case of the work of CONAN et al.(1981) it seems that divergence in the parameters is bound to sample problems (partial representation of the population) and to otolith reading. With regard to results relative to males our parameters are very different from those estimated by RODRIGUEZ et al.(1985) and AUBIN OTTENHEIMER (1986). The causes remain unexplained taking, account of the effect of reading harmonization. It seems probable that the results from these authors are , under - estimated in the case of L_{∞} (and for instance over-estimated for K). In fact, there are males from Megrim catches by the french fleet in the same fish area, which reach 49 cm in length. This under-estimation would be proceed from a bias introduced during the sampling (bad differenciation between males and females).

5. Conclusion.

Agreement on Megrim otolith reading by Spanish and French teams is an element which will allow harmonization of the data base necessary to the dynamic stock study, from the Celtic sea. This must contribute to improved reliability of the diagnosis concerning the management of this resource.

The use of a new fitting data model to the Von BERTALANFFY growth model allows the optimization of growth parameters L_{∞} and K for Megrim males and females. More ever this reveals that the choice of the length distribution mean to a given age like fitting central value appears to be ill-adapted. This use, systematically in the past, is now open to question.

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Age (years)	Mean (cm)	Median (cm)	Mode (cm)	Number of observations
2	17.73	19.50	18.63	19
3	21.56	23.05	21.62	74
4	24.22	25.88	25.40	61
5	27.18	28.71	27.71	16
6	29.60	31.33	30.67	10
7	30.50	31.00	31.00	4

Table (1) : Age - length relationship for Megrim males. Fitting central values observed by age class.

Age (years)	Mean (cm)	Median (cm)	Mode (cm)	Number of observations
2	18.44	20.30	19.50	9
3	24.54	26.19	25.45	115
4	28.48	29.84	28.53	49
5	31.77	32.00	31.42	44
6	36.28	37.60	34.77	32
7	39.29	40.90	40.00	23
8	42.41	43.40	40.73	34
9	44.76	45.70	44.37	17
10	46.12	47.00	47.50	8
11	46.42	47.75	46.50	7
12	46.75	47.00	46.83	4

Table (2) : Age - length relationship for Megrim females. Fitting central values observed by age class.

Age (years)	Mean (cm)	Median (cm)	Mode (cm)	Number of observations
2	18.38	19.45	18.18	19
3	21.93	23.03	21.93	74
4	24.94	26.02	25.13	61
5	27.50	28.51	27.85	16
6	29.68	30.58	30.18	10
7	31.53	32.30	32.16	4

Table (3) : Length central values predicted by the fitting model for Megrim males.

	Mean	Median	Mode
L_∞	45.54	43.67	42.59
Variance	9.49	2.82	3.51
K	0.11	0.14	0.16
Variance	0.0015	0.0049	0.022
T_0	- 2.02	- 1.76	- 1.25
Variance	0.13	0.36	0.03
Residual variance	618.97	611.30	666.00

Table (4) : Estimated growth parameters (L_∞ , K , T_0) with their variances, for Megrim males, for the three fitting length central values.

Age (years)	Mean (cm)	Median (cm)	Mode (cm)	Number of observations
2	19.56	21.02	20.94	9
3	24.76	25.81	25.05	115
4	29.29	30.05	28.82	49
5	33.22	33.80	32.28	44
6	36.65	37.12	35.44	32
7	39.63	40.05	38.34	23
8	42.22	42.64	40.99	34
9	44.47	44.93	43.43	17
10	46.43	46.96	45.67	8
11	48.13	48.75	47.71	7
12	49.62	50.34	49.58	4

Table (5) : Length central value predicted by the fitting model for Megrim females.

	Mean	Median	Mode
L_∞	60.01	63.26	65.19
Variance	5.19	16.81	4.12
K	0.14	0.12	0.09
Variance	0.0002	0.0035	0.007
T_0	- 0.82	- 1.31	- 1.87
Variance	0.36	0.11	0.68
Residual variance	1458.98	1297.05	1004.79

Table (6) : Estimated growth parameters (L_∞ , K , T_0) with their variances, for Megrim females, for the three fitting length central values.

	MALES			FEMALES			
	L_∞	K	T_o	L_∞	K	T_o	
CONAN et al. (1981)	-	-	-	50.88	0.21	0.18	
RODRIGUEZ et al. (1985)	39.36	0.29	-0.14	63.13	0.11	0.07	
AUBIN OTTENHEIMER (1986)	38.45	0.34	0.06	59.63	0.14	0.50	(1)
	38.84	0.32	0.02	60.22	0.14	0.46	(2)
MOGUEDET et al. (1988)	45.54	0.11	-2.02	60.01	0.14	-0.82	(3)
	43.67	0.14	-1.76	63.26	0.12	-1.31	(4)
	42.59	0.16	-1.25	65.19	0.09	-1.87	(5)

(1) Fitting using the mean and a ponderation by the sample size.
(2) " " " " " " " " variance.

(3) Fitting using the mean and a ponderation by the sample size.
(4) " " " median " " " " " .
(5) " " " mode " " " " " .

Table (7) : Summary of the various estimations of the V. BERTALANFFY growth model parameters.

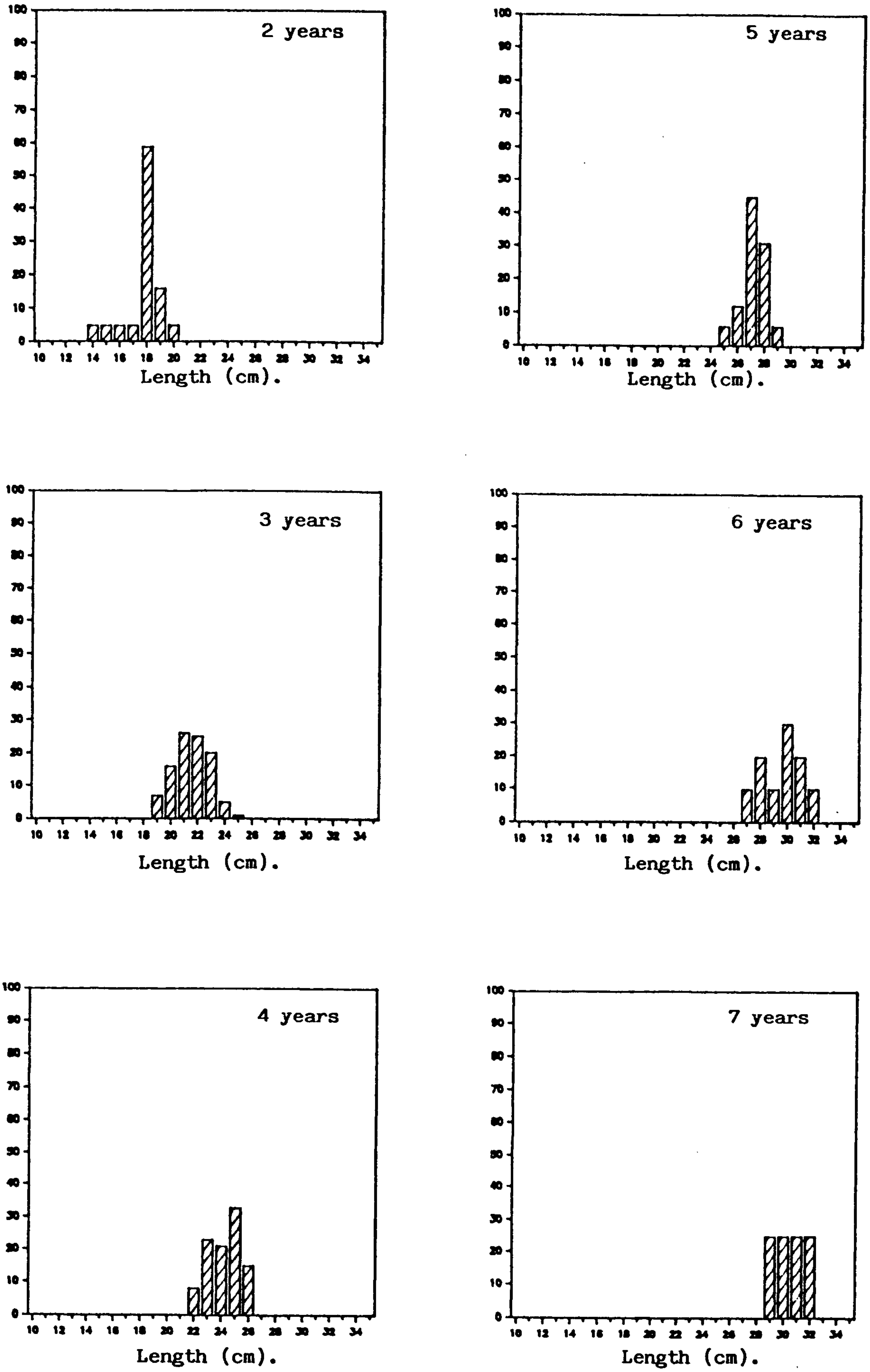


Figure (1) : Histograms of the length distribution of the otoliths sample (in %) by age class for Megrim males.

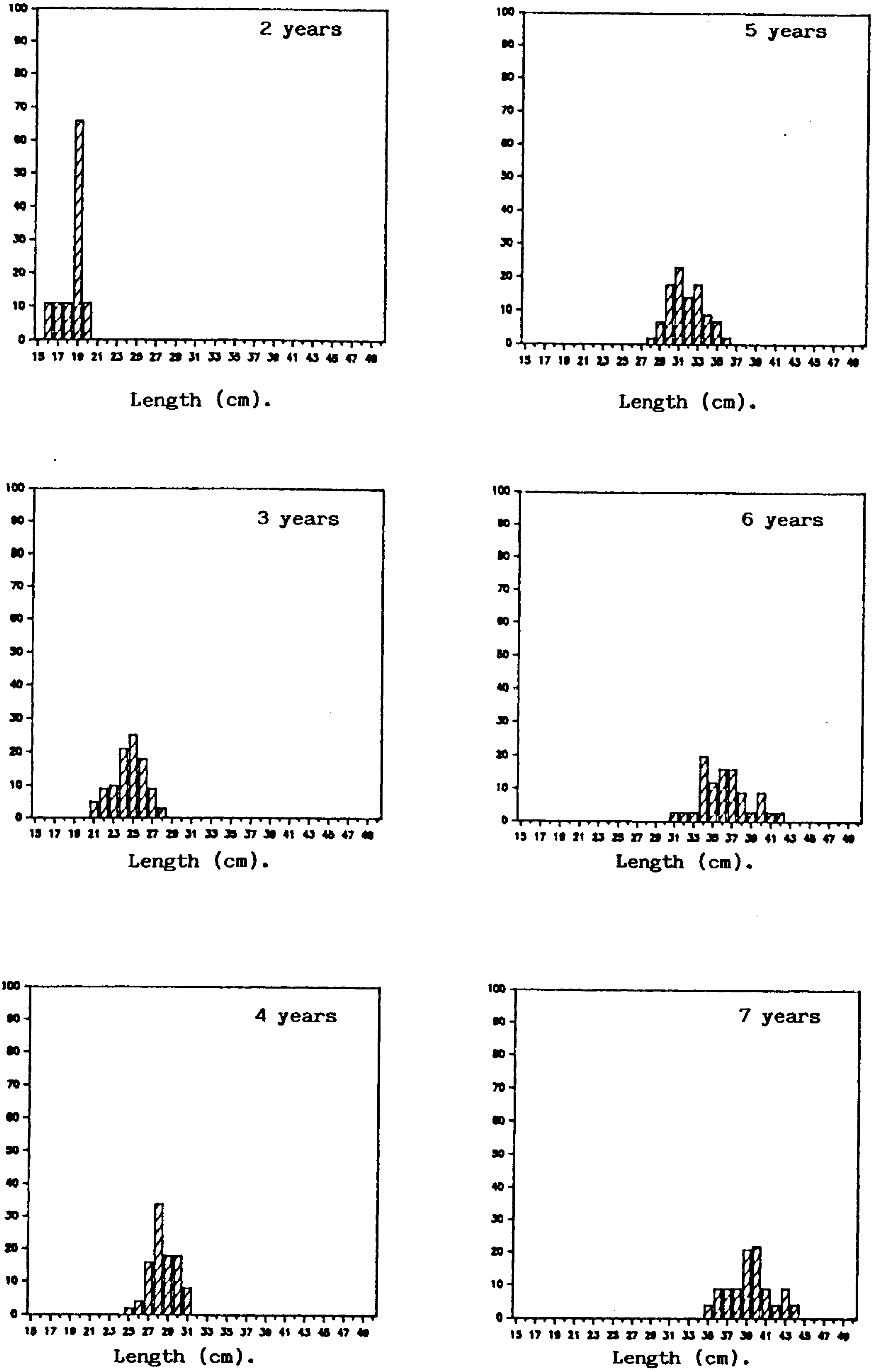
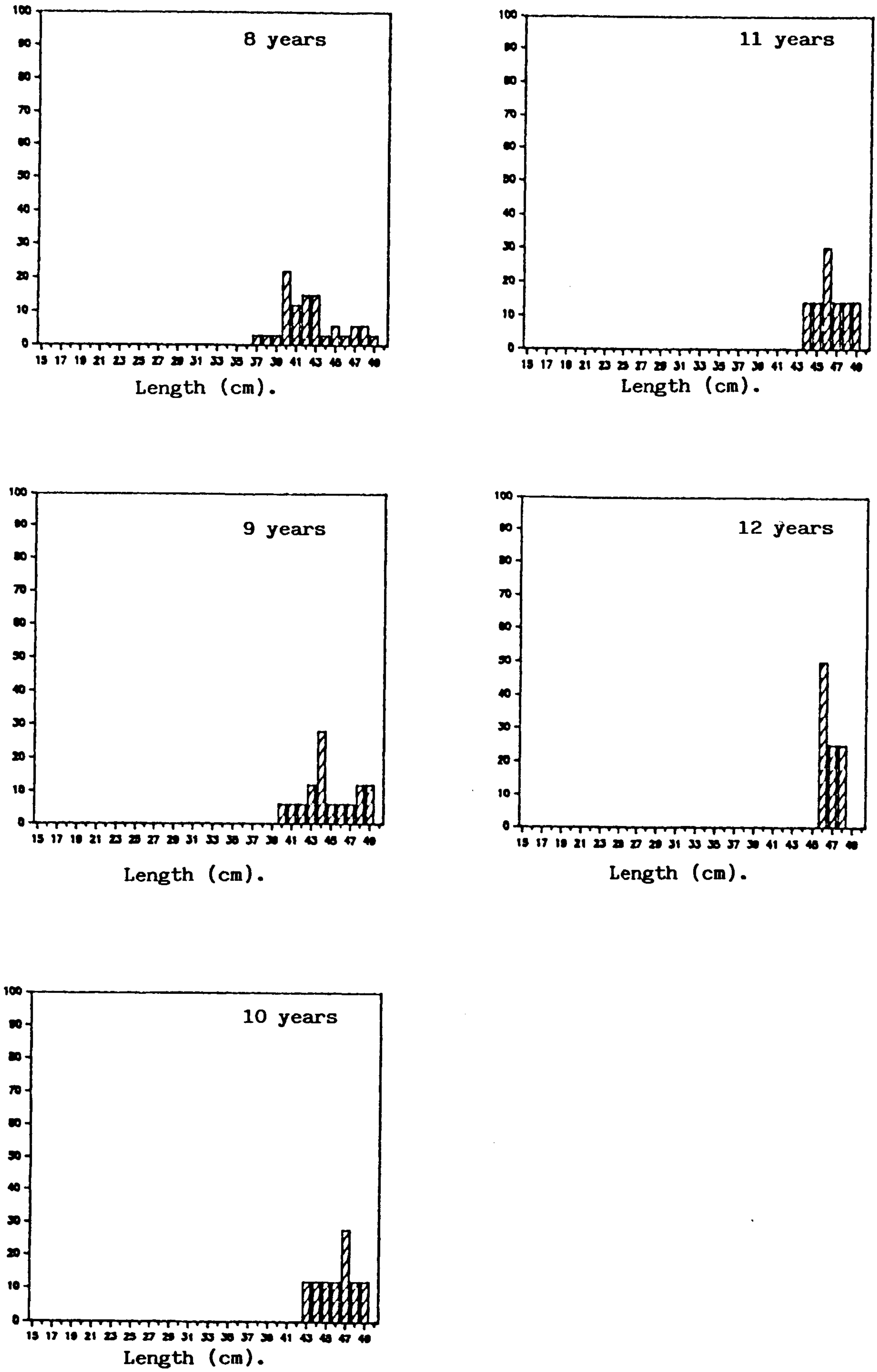
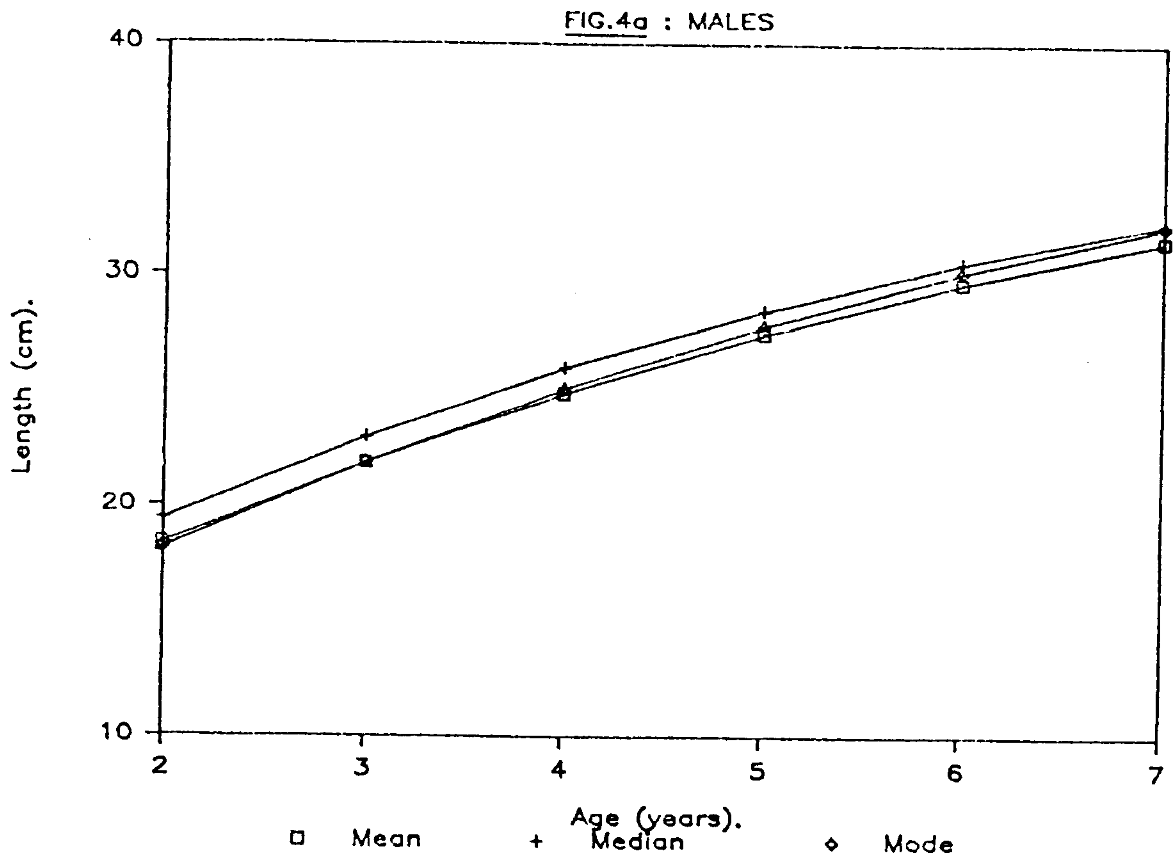


Figure (2) : Histograms of the length distribution of the otoliths sample (in %) by age class for Megrim females.



<u>Figure (3)</u> : Histograms of the length distribution of the otoliths sample (in %) by age class for Megrim <u>females</u>.



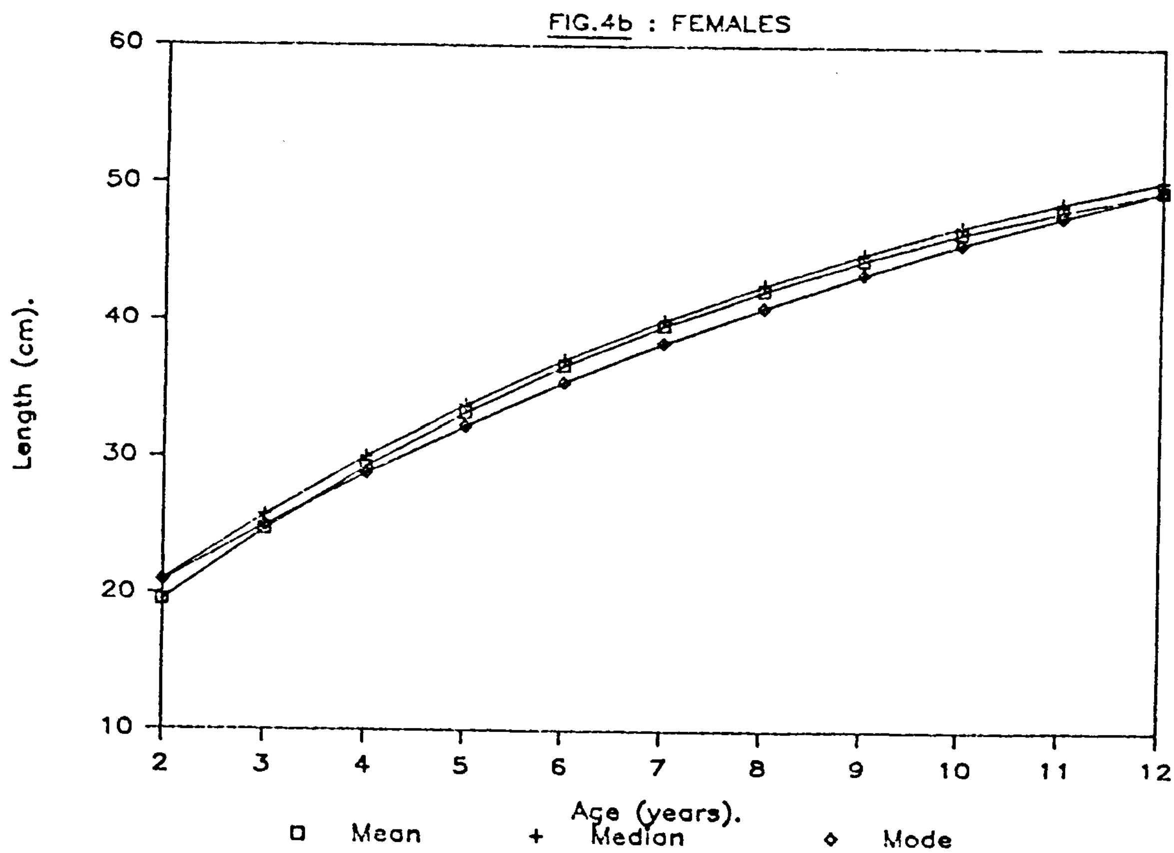


Figure (4) : Von BERTALANFFY growth curves for Megrim males and females.