

**ON THE GROWTH OF THE MEDITERRANEAN HAKE (*Merluccius merluccius* L.)
FROM THE SANTA POLA BAY (S.E.SPAIN)**

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Introduction

The hake, *Merluccius merluccius* (Linnaeus, 1758), is a widely distributed groundfish species on the continental shelf and slope off Europe and in the Mediterranean Sea at depths between 30 and 1 000 m, though it is most abundant between 70 and 370 m. The species carries out daily vertical feeding migrations, staying close to the bottom in the daytime and rising off the bottom to adopt a midwater habit at night, and is a target species in trawl fisheries.

Materials and methods

The data were compiled from monthly samples collected from landings by the commercial fleet at the Santa Pola (Figure 1) fish wharf in 1991, 1992, and 1993. A total of 72 samples, two per month, were collected from January 1991 to December 1993, contributing a total of 20 806 individuals, measuring its individual total length at the nearest lower cm; in each month some individuals were intensively sampled; total length in cm; total weight in g; gutted weight in g; and girth around the base of the pectoral fins in cm; separately by sexes, were recorded from a total of 2 889 individuals.



Figure 1.- Situation of the area of study

The relationships between certain parameters considered were determined. For total length:total weight and girth:total weight, the data was expressed by a power equation of the form $W = a \cdot L^b$. For the other parameter relationships, total weight:gutted weight and total length:girth, the data was adjusted by linear regression: $Y = a + bX$. The relationships were established separately for males, females, individuals of undetermined sex, and the population as a whole.

The age-length relationship was computed from size frequencies. Monthly data samples were expanded to the total number of individuals caught per month by the fleet, and grouped by 2-cm size class, separated by sexes using the sex ratio by size, and smoothed over three classes; the pool of individuals for which sex could not be determined was divided equally between males and females. The Von Bertalanffy growth function (VBGF) $L_t = L_\infty (1 - e^{-k(t-t_0)})$ was employed as growth expression and the growth parameters (L_∞ , K and t_0) estimated using the ELEFAN (Gayanilo et al. 1988) and FISHPARM (Prager et al. 1987) automatic computer programs. Estimations of the "best combination" of the VBGF parameters were done, looking to optimize the values of the goodness index (R_n), and giving a value of $t_1 = 12$ cm to determine t . The

method of Bhattacharia (MPA mode of the ELEFAN program) was applied to the data quarterly and the results were then applied to the FISHPARM program.

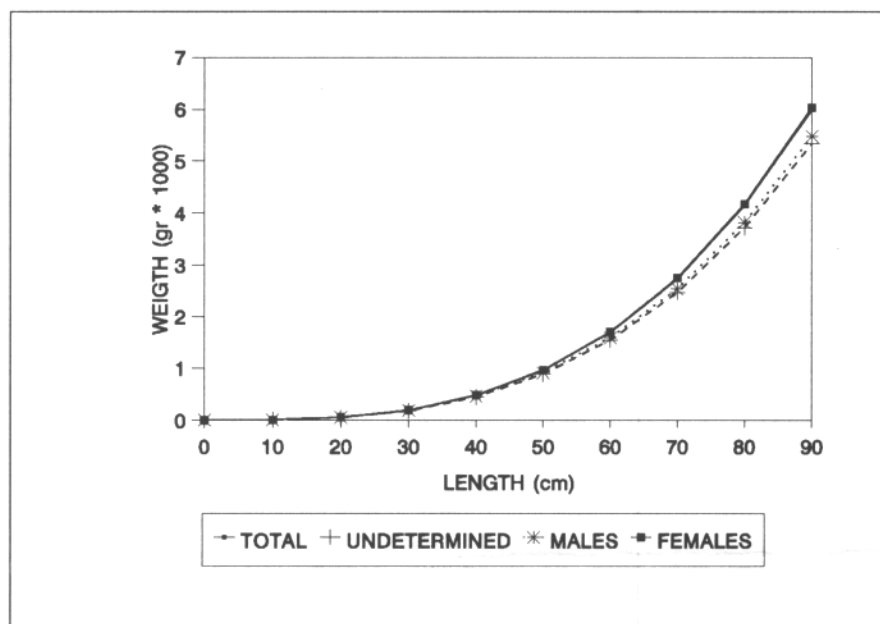


Figure 2. Curves of relative growth (Length-Weight) for the hake by sex.

Results

The results for the relationships between the various biometric parameters for hake established in this study have been presented as follows: The **length-weight** relationships are presented in Table I, resulting that the coefficient b

significantly differ than 3 in all cases except in males, which is graphically represented in Figure 2, showing that the curves of the females and total population overlap each other and, on the other hand, undetermined and males also overlap;

TABLE I.- Parameters of relative growth (Length-Weight relationship: $Weight = a \cdot Length^b$) calculated for the different groups (undetermined, males, females and total) of *Merluccius merluccius*; significance levels = ***<0.001, **<0.01, *<0.05 y NS<0.1 in a "t"Test.

Group	a	b	err.b	signif.	r2	n	range
males	0.006	3.05	0.02941	NS	0.96	502	13.5-52.5
females	0.0048	3.12	0.01259	***	0.99	955	11.5-68.0
undeterm.	0.0056	3.06	0.01681	***	0.96	1 369	4.0-32.5
total	0.0048	3.12	0.00477	***	0.99	2 826	4.0-68.0

The **girth-weight** relationships are presented in Table II, show a significant difference between b and 3 in all cases except in the undetermined, showing that its growth curves (Figure 3) coincide between those of males and females, yielding lesser weights at the same girth than undetermined and total population; the **girth-length** relationships are

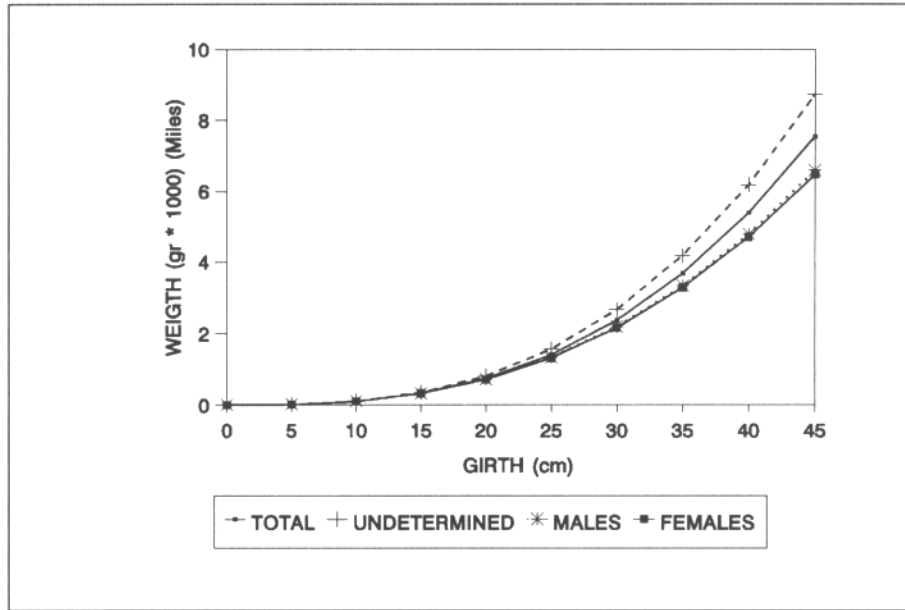


Figure 3. Curves of relative growth (Girth-Weight) in hake by sex.

presented in Table III, resulting a relation between parameters in the form that the girth is nearly the half of the length; and the **guttled weight-total weight** relationships are shown in Table IV.

TABLE II.- Parameters of relative growth (Girth-Total Weight relationship: $Weight = a * Girth^b$) calculated for the different groups (undetermined, males, females and total) of *Merluccius merluccius*; significance levels = ***<0.001, **<0.01, *<0.05 y NS<0.1 in a "t"Test.

Group	a	b	err.b	signif.	r2	n	range
males	0.210	2.72	0.03390	***	0.93	437	13.5-52.5
females	0.214	2.71	0.01683	***	0.96	819	11.5-68.0
undeterm.	0.125	2.93	0.02464	NS	0.91	1 230	4.0-32.5
total	0.141	2.86	0.00675	***	0.99	2 486	4.0-68.0

TABLE III.- Parameters of relative growth (Length-Girth relationship: $Girth = a + b Length$) calculated for the different groups (undetermined, males, females and total) of *Merluccius merluccius*.

Group	a	b	r2	n	range
males	-0.289	0.42	0.86	437	13.5-52.5
females	-1.552	0.48	0.92	819	11.5-68.5
undeterm.	0.080	0.38	0.90	1 230	4.0-32.5
total	-0.995	0.46	0.97	2 486	4.0-68.5

The size-weight relationship values shown, were similar to the values calculated by other workers in the Western Mediterranean, see Quesada (1991), resulting in general that the values of b were higher than 3. Differences between group sizes were small and were mainly ascribable to the fact that the size ranges for the individuals of undetermined sex and for males were smaller than the size range for females; for the segment of the size range covered by all three

of these groups the growth curves overlaps, suggesting that any differences were not significant. The value of the allometric coefficient b was significantly greater than 3, indicative of a slightly positive allometry in the growth of hake in the Mediterranean over its entire life span, except for males in which case were not different from 3 being its growth isometric, resulting that females were more robust than males.

TABLE IV.- Parameters of relative growth (Gutted Weigth-Total Weigth relationship: Gutted Weigth = $a + b$ Total Weigth) calculated for the different groups (undetermined, males, females and total) of *Merluccius merluccius*.

Group	a	b	r2	n	range
males	2.11	0.88	0.96	502	13.5-52.5
females	5.91	0.85	0.99	955	11.5-68.0
undeterm.	1.50	0.80	0.94	956	4.0-32.5
total	3.22	0.86	0.99	2 413	4.0-68.0

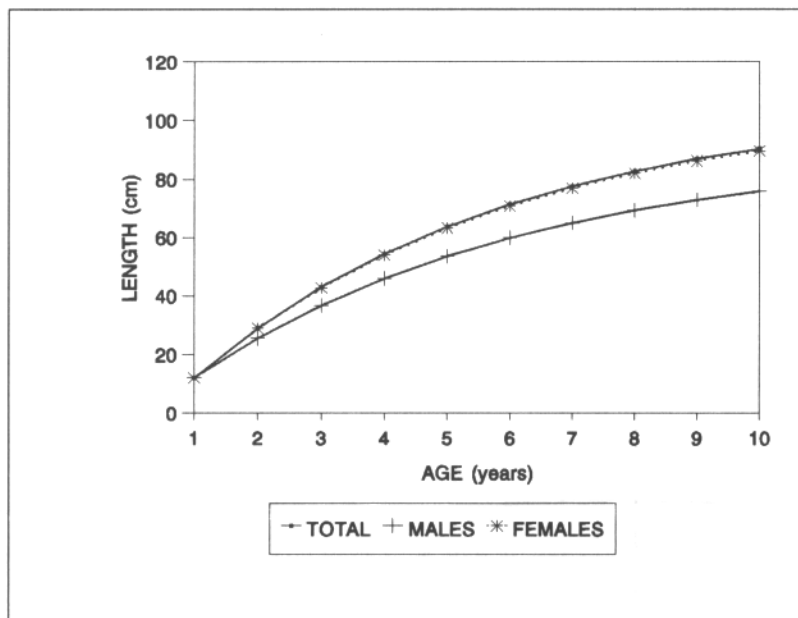


Figure 4. Curves of the absolute growth (Length-Age) of hake, using the ELEFAN program

The **age-length** relationship result shows, in general, a growth rate higher than accepted until now: The results of the different estimations yielded by the ELEFAN program are shown in Table V, showing in Figure 4 the growth curves; for the parameters calculated by the use of the FISHPARM program, the results of the different estimations done, appear in Table VI, while the absolute growth curve appears in Figure 5. The results for the calculations of the VBGF parameter values indicate that the two programs yielded comparable estimates. Growth

differences between the sexes appeared in the second year of life, and the K values produced by the programs differed, the ELEFAN estimate being higher. In both cases the curves of the females and total population overlaps, being higher than the males ones.

TABLE V.- Results of the growth parameters (length- age relationship) of the VBGF ($L_t = L_\infty (1 - e^{-k(t-t_0)})$) obtained using the ELEFAN program, for the different groups (males, females and total) in *Merluccius merluccius*.

Group	L_∞	K	t_0	Rn
males	90	0.19	0.24	0.108
females	105	0.20	0.39	0.142
total	106	0.20	0.40	0.132

TABLE VI.- Results of the growth parameters (length- age relationship) of the VBGF ($L_t = L_{\infty} (1 - e^{-k(t-t_0)})$) obtained using the FISHPARM program, for the different groups (males, females and total) in *Merluccius merluccius*.

Group	L_{∞}	K	t_0
males	73.3	0.172	- 0.108
females	99.7	0.153	0.264
total	113.2	0.123	0.137

We recomend for its application, as a result of this work, the use of the FISHPARM parameters, due to the low values of the goodness index (Rn) obtained in the calculations of the ELEFAN growth parameters. In general the age of the individuals caught by trawl did not exceed 7-8 years old, implying that the species not live longer than 10 years.

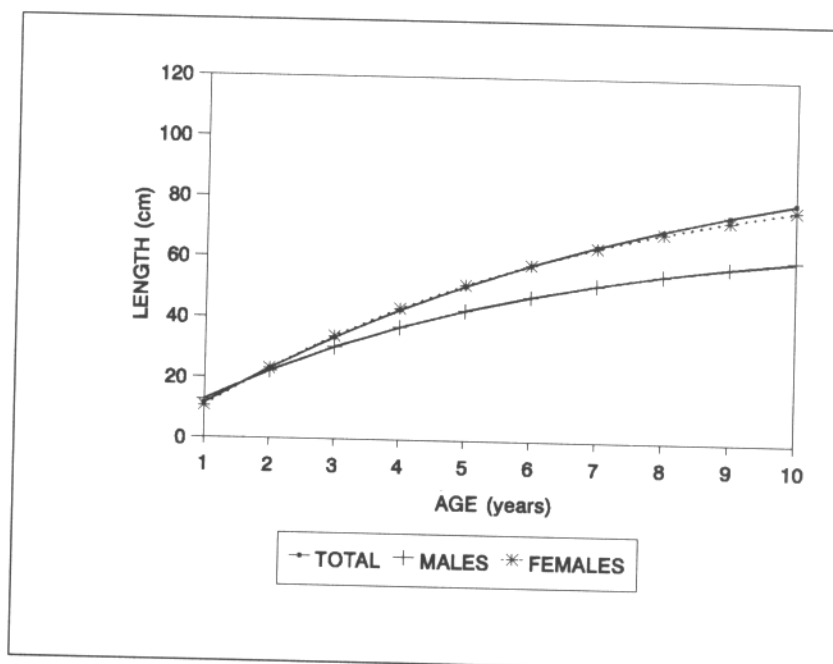


Figure 5. Curves of absolute growth (Length-Age) in hake using the FISHPARM program.

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