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Growth features of American plaice *Hippoglossoides platessoides* in Northwest Atlantic

by

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Abstract

The growth pattern for American plaice (*Hippoglossoides platessoides*) for two different populations in the Northwest Atlantic, the Grand Bank (3NO) population and the Flemish Cap (3M) population is modelled. Two non linear models are used from the Von Bertalanffy model in order to know the parameters involved in the equation. Results show that the youngest individuals of 3M growth faster than the 3NO individuals, although there is an intersection point between the two populations, around 38 cm for males and 51 cm in females, in which the growth of the 3NO American plaice is higher in both sexes. This population reaches higher lengths for both sexes. We discuss the possibility that the ontogenic changes in the feeding and the variations in the energy allocation for different reproductive needs could better explain the growth changes than the differences of temperature.

Introduction

Individual growth of fishes is one of the most important parameters in life-history theory. Indeed, growth of living organisms is a very complex process. Besides its dependence on behaviour, fish growth depends on environmental factors (mainly food and temperature) and genetic properties. For coldwater fishes, Gjedrem (2000) found that 70-80% of the growth is determined by environmental factors, while the remained part is ascribed to genetic properties.

The most common way to study environmental effects on fish growth in the environmental field is by time series analysis. In doing this, changes in growth are related to environmental variables, and thus the different environmental variables evaluated to respect to growth. Optimal environmental conditions for fishes are both species and size specific (Jobling, 1994, BjØrnsson *et al.*, 2001) which mean that growth conditions in a certain ecosystem can be optimal for some species at a specific life stage, but not necessarily for other species or for the smaller and larger individuals.

In general, it can be assumed that abundant food supply, and usually also high temperature, favour the growth rate. This implies that for a species there may be great variation between areas. It is known that some areas (ecosystems) are more productive than others.

In the Northwest Atlantic, flatfishes of the Pleuronectidade family (right-eye flounders) are second in importance in bottom fish communities dominated by gadoids. The species long rough dab (*Hippoglossoides platessoides*, Fabricius 1780), known as American plaice on the western side of the North Atlantic, has a distribution similar to cod (*Gadus morhua*, Linnaeus 1758). This species is one of the most important traditional fishing resources in the Northwest Atlantic. The stock, that is distributed (inhabiting) on the Newfoundland-Labrador Shelf (NAFO Divisions 3LMNO), has been under quota management since 1973. There are two admitted American plaice stocks in this area, the Grand Bank stock (Div. 3LNO) and the Flemish Cap stock (Div. 3M) (Morgan and Bowering, 2006).

Both populations have declined in abundance to very low levels and are under moratoria to directed fishing (Alpoim *et al.*, MS 2002; Morgan *et al.*, 2002; Morgan *et al.*, MS 2003). Extensive overexploitation over many years in combination with climate change represents a potential evolutionary pressure towards changes in growth, lower age at maturity and increased in fecundity (Kjesbu and Witthames, 2007).

The biology and ecology of American plaice in the Northwest Atlantic have been deeply studied since the 60´s (Pitt, 1966, 1967), going on subsequently (Bowering and Brodie, 1994; Morgan and Bowering, 2006) and extending the studies to the both sides of the North Atlantic (Walsh, 1994 and 1996).

For several stocks of American plaice maximum age seems to be closely correlated to the age at sexual maturity (Walsh, 1994), although the reasons for this correlation are not fully understood. There are very well-known empiric differences among the life traits for both populations, 3LNO (Grand Bank) and 3M (Flemish Cap), being the most outstanding the difference among the abundances, much smaller in Flemish Cap than in the Grand Bank. Maximum length at catches and also data from surveys both indicate that the maximum size reached by the individuals from the Grand Bank is always bigger than that of the individuals of Flemish Cap, where the age range is much narrower. The data of the literature show differences in the age of first maturation in the individuals of 3LNO and 3M (Pitt, 1966; Zamarro, 1992).

Studies comparing maximum age, mortality rate, asymptotic length and growth rate, indicate direct relationships between growth rate and mortality rate. Maximum age and asymptotic length are closely correlated, and inverse correlations occur for maximum age-mortality rate and asymptotic length-growth rate comparisons. Comparisons with environmental data indicate that growth rate is affected by temperature and that asymptotic length is affected by food and temperature. Growth rate varies with log temperature and is closely related to metabolic rate and activity. Comparisons of the ratio length at maturity/asymptotic length with maximum age suggest that high ratios are related to short lifespans (Beverton and Holt, 1959). Therefore growth rate can be symptom of a different vital strategy, because a slower growth, as the one reported for the American plaice 3NO, could favour its longevity and maximum size, as well as some bigger size and age of first maturation.

Although there are several studies about growth for this species, some of them do not make difference by sex (Straoudakis *et al.*, 1997), and other do not study the growth by year class, instead several age groups by year are modelled (Fossen *et al.*, 1999). Moreover, there are no studies comparing the growth among populations from the Northwest Atlantic, i.e. Grand Bank and Flemish Cap.

American plaice (*Hippoglossoides platessoides*) on the Grand Bank (Divisions 3LNO) and Flemish Cap (Div. 3M) are thought to represent separate populations. In the late 1980s and early 1990s there was a change in the distribution of American plaice in the region. An examination of distribution, growth, age composition and maturity by Bowering and Brodie (1994) indicated that American plaice on the Flemish Cap were distributed in warmer waters, were bigger at age and had a truncated age distribution compared to fish on the Grand Bank.

In this work we model and compare the growth of the American plaice in 3NO and 3M for cohorts and for sex. In this way we try the hypothesis that relates the rate of growth with the maximum size to make a will and to check if there are variations in the growth to the lake of the life.

The aim of this work is to modulate and compare the growth pattern of the American plaice from the data obtained in the Spanish and EU surveys performed in 3NO and 3M, both intra-area and inter-area.

Material and Methods

Data

Data from length frequency distribution for American plaice in both areas were available from annual surveys samples: 3NO Spanish bottom trawl survey and Flemish Cap EU (Spain and Portugal) bottom trawl survey. For details of the surveys procedure see Vázquez, 1999; Durán Muñoz *et al.*, 2001. Although the stock of the Grand Bank inhabits the Div. 3LNO and the Spanish bottom survey is carried out only in Div. 3NO, with the fall in the population the last years the stock has been concentrated in the Div. 3NO (Brodie, 2002), so the survey can be considered significant of the situation in the whole 3LNO area.

Table 1 presents a summary with the years, the vessels and the number of hauls and depths by year covered by the surveys. In 2001, the former vessel in the 3NO survey was replaced by the R/V *Vizconde de Eza*. Likewise, in 2004 the same procedure was made for the 3M survey, in which the depth strata covered was extended to reach the 1400 m. Calibrations were made in both cases in order to transform the data from the former vessel into the new vessel units (González-Troncoso *et al.*, 2004, González-Troncoso and Casas, 2005). As American plaice is a no-deep water species, the data for this species suffered no changes with the extend of the depth, so the periods are comparable.

Age information was obtained from age length key (ALK) provided by Karen Dwyer and Joanne Morgan (DFO, Canada) for Grand Bank and by Ricardo Alpoim (IPIMAR, Portugal) for Flemish Cap.

For 3NO we used the mean length data obtained from the Spanish surveys between 1997 and 2006 for a *Campelen* gear. For 3M, there are data available from 1988 to 2006 with a *Lofoten* gear, but we used only the data from 1995 to 2006 because the previous data hardly contribute to the studied cohorts. All the data were previously transformed to R/V *Vizconde de Eza* values.

Besides that, the 3M data were transformed to the *Campelen* values in order to be able to compare the two gears (and the selectivities). For that, we converted the length distribution from the *Lofoten* gear into the *Campelen* gear, using the following multiplicative model, proposed by Warren (1997):

$$Ratio = \alpha l^{\beta} e^{\delta l}$$

where:

$$Ratio = \frac{Campelen\ Catch}{Pedreira\ Catch} \text{ by length}$$

l is the length

$\alpha,\ \beta\ and\ \delta$ are the estimated parameters.

For more details about this method, see Paz *et al.* (2002). To perform the transformation, data from hauls carried out with the two gears alternately in the 3M surveys of 1999, 2000 and 2001 were used. The transformation curve is almost lineal around two, what indicates that the *Campelen* gear fishes the double of all lengths of American plaice than the *Lofoten* gear. So, the results obtained before and after the transformation are practically the same, as the transformation is almost lineal and we are made a comparison. Figure 1 shows the fit and the parameters of the transformation.

In Table 2 we present a summary of the available and the used data in this study. No all the data available can be used because the non linear model used did not converge. We used the common cohorts in order to compare the different cases that we can compare. The available ages were 1-16 for 3M and 1-20 for 3NO.

The mean age length estimated by sex from age length key was tested with the modal progression values in the length distribution data from the 3NO Spanish research survey for a period 1999-2006. The analysis was possible because the presence of an important year-class showed a high modal value.

Models

The Von Bertalanffy model was used to represent the growth of the American plaice in the different cohorts:

$$l_t = l_\infty \left(1 - e^{-k(t-t_0)}\right) \qquad (1)$$

where:

l_∞ is the maximum length that the species reaches,

k is the body growth rate. In the same conditions of the other parameters, the bigger that k is, the faster the species reaches the maximum length,

t_0 is the cut point of the graph with the abscissa

A robust parametrization of the von Bertalanffy model (Schnute, 1891; Ratkowski, 1986) was used to obtain the growth rate that describes the length at age of American plaice:

$$l_t = l_1 + (l_2 - l_1) * \frac{1 - e^{-k(t - t_1)}}{1 - e^{-k(t_2 - t_1)}} \qquad (2)$$

where:

t_1, t_2 are the youngest and the oldest observed ages in the cohort

l_1, l_2 are the corresponding mean lengths to t_1 and t_2.

To obtain a robust estimated growth rate, we use (2) by a non linear least squares regression by cohort and by sex using the available ages with their corresponding mean length, and then we obtain l_∞ and t_0 by fitting (1) with non linear least squares.

All the statistical analysis was made in R (www.flr-project.org).

Growth models were fitted to the data from the Grand Bank and Flemish Cap by non linear least squares regression. Data were analyzed by sex and by cohort.

Results

Modal progression of an exceptionally large year class. The mean length of the 1997 cohort were used to carry out three modal progression analysis. Data were taken from 1999-2006 May-June bottom trawl surveys. The strength of this year-class has been seen in previous studies (González-Troncoso *et al.*, 2007). We obtained the mean length by converting length distributions of total survey catches into age distributions and subsequently estimating the mean length-at-age for each derived age group. Surveys-specific age-length keys (ALKs) based on otolith age determinations were used (Joanne Morgan personal communication). When there was a gap in the data of a cohort (as in a year that failed an age class), we obtain the mean length as the mean of the mean lengths of the previous and the following ages of that cohort.

Test to the mean length at age. The mean length at age estimated by sex from age length key were tested with the modal progression values in the length distribution data from the 3NO Spanish research survey for the period 1999-2006 (Table 3) (González-Troncoso *et al.*, 2007). For female the considered age interval was 2 to 9 age older and for males was 3 to 8 age older.

In the figures 2 and 3 appears the regressions fitted, the function with parameters values obtained and the confidence interval to 99%.

In the two plots we can see the agreement within the mean length values obtained from the age-length key and the modal values in the length distribution from the catches in the survey. The high values R^2 for females and males: 0.9908 and 0.9932 respectively and the point situation inside 99% confidence interval indicates good correspondence.

Although there are few available and considered points, the agreement obtained between mean length values and the modal values permits to use the mean length at age values obtained from otoliths as the accurate values corresponding to the age for the 3NO American plaice population. These values were used to model the growth of the 3NO American plaice population.

For 3M American plaice the ALK used was the available for this population obtained from EU survey.

Comparison of length distribution and longevity. The maximum length in the length distribution samples from Grand Bank is 76.5 cm., 16 cm greater than the maximum length in the Flemish Cap (60.5 cm.) (Table 4). We can observe that the maximum mean length at age is always higher in females than in males, a well-know fact in this species, and higher in the 3NO population than in the 3M population for both sexes (Table 5, Figure 4), indicating more longevity. The length difference (in mean) was greater in females: 16 cm. versus 8.5 cm. for males.

Comparison of growth. We first fitted the Von Bertalanffy model as we explain above for all the available cohorts-10 cohorts for 3M males, 15 cohorts for 3M Females, 10 cohorts for 3NO males and 18 cohorts for 3NO females. In order to know the distribution of the parameters, we made a bootstrap among the parameters of all the cohorts. We made 5000 runs of the Von Bertalanffy model over the parameters, but as no all the cases converge, we obtain fewer results, with different number in each case. Figure 5 (a-d) shows the histogram of some of the results for the principal parameter of the model, the growth rate k, as the number of booststrap obtained. We can see that this parameter is almost normal-distributed. No all the cohorts have “logical” values for them. For example, the 1989 cohort of the 3M females has a l_∞ of 114.259, what is impossible.

Then we tried to compare the *inter* and the *intra* zone mean lengths by cohort. For the intrazone comparison we compared the mean length of each area by sex, and interzone we compare the same sex within areas. So, we have four cases of study, which are:

-Intrazone 3M: compare 3M males and females. Common cohorts: 1990-1999.
-Intrazone 3NO: compare 3NO males and females. Common cohorts: 1993-2002.
-Interzone Males: compare 3M males and 3NO males. Common cohorts: 1993-1999.
-Interzone Females: compare 3M females and 3NO females. Common cohorts: 1985-1999.

In figure 6 (a-d) the results of the Von Bertalanffy curves, with the two principal parameters of the curve, k and l_∞, the mean length estimated from ALK and length distribution and the fitted mean length by age, as the cut point between the two cases studied each time, are shown. Although as it was mentioned above there are some cohorts that have no logical values, normally the fit of the real points are good, so we show all the graphs for all the cases.

We can see that, in general, females growth more and slower than males, both in 3M and 3NO (Figures 6a and 6b). This is coherent with a higher k in males than in females in both cases, with a mean of 0.38 ± 0.22 and 0.18 ± 0.09 for males and females of 3M, respectively, and 0.16 ± 0.08 and 0.07 ± 0.06 for males and females of 3NO, respectively (these means are made only with the positive values of k) (Table 6). When the two curves cut, the cut point is in the youngest ages, about 3 years old, and then females raised up. In most cases, the l_∞ for females is around 60 cm, and the one for males is around 40 cm. About interzones, it seems that in the first stages of the life the individuals of 3M growth faster that the ones in 3NO, but there is some point that the growth of the 3NO individuals changes and exceeds the growth of the 3M individuals. This point, that can be easily see in the graphs, is around 38 cm for males and 51 cm in females. In the whole of the cohorts it can be seen that k is higher in 3M than in 3NO for both sexes, as we can see above in the values of the l mean.

Discussion

Flemish Cap is an isolate bank, so it is logical to think that the American plaice population in it is totally separated from the Grand Bank American plaice population. In this study we present some results that seem to strengthen this belief. Once we fit the growth, both populations show different patterns, according to their different vital strategies. The faster growth in 3M population matches with a higher natural mortality and a lower length of maturity and less longevity.

American plaice collected from the western (Div. 3L) and eastern (Div. 3M) sides of the Flemish Pass were clearly different in mean length-at-age and in their maturation, with fish from the eastern side being larger at age and females maturing at a smaller size than those from the western or Grand Bank side of the Flemish Pass. Further, American plaice were not collected in the deepest part of the Pass that was surveyed. Thus it seems that fish in the Flemish Pass area are not mixing but rather are separate groups (Morgan and Bowering, 2006).

An intersection point between the two fitted curves of the two populations in which the growth of the 3NO American plaice is higher than the 3M American plaice growth in both sexes can be seen. The change in the rate of growth of the adults between both populations since certain age seems to be no because environmental factors due to the periodic and regular pattern of them. The faster growth in the 3M American plaice for the youngest was studied for other authors that found that the growth rate of many invertebrate and fish species appears to be higher on the Flemish Cap that on the Grand Bank, despite the relative small distance between these areas (Bowering and Brodie, 1994; Morgan and Bowering, 2006). In 3M a higher first and second production than in 3NO can be observed due to the physical and chemical differences between the two areas (Maillet *et al.*, 2005). For that, the diet in 3M is richer in energy. This could explain the faster growth in the youngest individuals in 3M.

The densities of American plaice observed in most years in Flemish Cap strata were considerably lower than for adjacent Grand Bank strata, where average catches were often greater than 100 Kg/tow over side areas during 1970s and 1980s (Brodie MS 1988). Besides that, the bottom temperature found on Flemish Cap were much higher than those found at similar depths on the Grand Bank during the same period (Morgan and Brodie, 1991). It is known that both factors, density and temperature, favour a faster growth (Lorenzen and Enberg, 2002; Pauly, 1980), and this could be the reason for the higher growth in young specimens of 3M, but they do not explain the different growth rate since certain age, when the 3NO American plaice growths faster and the 3M American plaice growth stops. Maybe the ontogenic changes in the feeding and the variations in the energy allocation for different reproductive needs could better explain the changes than the temperature. As in Flemish Cap the individuals mature before than in the Grand Bank, perhaps they need more feeding investment for breeding, so they have less amount of energy for growth. In the other hand, 3NO individuals could allocate that energy in remain growing.

As the result obtained in this study, Bowering and Brodie (1994) show that the growth rate were similar between sexes up to age 3 in the American plaice of 3M, however, beyond age 3, females grow faster.

Besides that, both populations show clear differences in their diet, as we can see in González and Paz, 2008. These authors showed that the Flemish Cap diet had higher energy, as well as the female diet was richer in energy in both areas. Differences in energy component of the diet between areas decreased when increasing the length for both sexes; it was linked to a diet change of the individuals in the Grand Bank from 38.1 cm in males and 50.9 cm in females. This result agrees with the cut point in the fitted curves and the differences in growth and longevity observed in each area for both sexes seeing above. The influence of the feeding in the differences of the populations could be reflected. The observed trend of diminishing energy differences between areas where the individuals are >30 cm is even more accused in the biggest individuals, and it would be in agreement with the superior growth rate in Flemish Cap, at the same time that a smaller l_∞ and longevity. The sizes where the growth pattern changes are close to those where the feeding pattern also changes.

In general, the growth rate k is higher in the 3M cohorts than in the 3NO ones for both sexes. This indicates, once again, that the 3M individuals growth faster than the 3NO individuals. The higher than k are, faster the individuals growth, and higher is the natural mortality, M. So, we can say than the 3M individuals growth faster but get a smaller asymptotic length, reach the age of first maturation before and die earlier (Beverton and Holt, 1959; Pauly, 1980; Froese and Binohlan, 2005). But as the k in this study is a general parameter for all cohort, we can not see in it the differences in growth since certain age. In Morgan and Bowering (2006) we can see how the growth rates in 3M decrease to the level of 3NO ones at age 10 for males and 11-12 for females.

It would be interesting to model a segmented regression to the Von Bertalanffy model in order to see the differences between the growth rate for the youngest and the oldest individuals in both areas. Perhaps in that case we could observe better the change in growth between the two populations.

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Table 1. Summary of the characteristic of the bottom trawl surveys on NAFO Div. 3NO and Div. 3M

EU 3M Survey				Spanish 3NO Survey			
Year	**Vessel**	**Valid tows**	**Depths**	**Year**	**Vessel**	**Valid tows**	**Depths**
1995	*R/V Cornide de Saavedra*	121	126-721				
1996	*R/V Cornide de Saavedra*	117	135-710				
1997	*R/V Cornide de Saavedra*	117	133-720	1997	C/V *Playa de Menduíña*	128	42-1263
1998	*R/V Cornide de Saavedra*	119	137-712	1998	C/V *Playa de Menduíña*	124	42-1390
1999	*R/V Cornide de Saavedra*	117	133-718	1999	C/V *Playa de Menduíña*	114	41-1381
2000	*R/V Cornide de Saavedra*	120	135-704	2000	C/V *Playa de Menduíña*	118	42-1401
2001	*R/V Cornide de Saavedra*	120	132-720	2001	R/V *Vizconde de Eza* C/V *Playa de Menduíña*	83 121	36-1156 40-1500
2002	*R/V Cornide de Saavedra*	120	130-740	2002	R/V *Vizconde de Eza*	125	38-1540
2003	*R/V Vizconde de Eza*	114	80-692	2003	R/V *Vizconde de Eza*	118	38-1666
2004	*R/V Vizconde de Eza*	177	135-1378	2004	R/V *Vizconde de Eza*	120	43-1539
2005	*R/V Vizconde de Eza*	176	132-1438	2005	R/V *Vizconde de Eza*	119	47-1485
2006	*R/V Vizconde de Eza*	179	134-1457	2006	R/V *Vizconde de Eza*	120	47-1485

Table 2. Data used in this study

	Available	**Used**	**3M Males**	**3M Females**	**3NO Males**	**3NO Females**
3M Males	1985-2002	1990-1999	-----	1990-1999	1993-1999	----
3M Females	1980-2002	1985-1999	1990-1999	----	----	1985-1999
3NO Males	1986-2004	1993-2002	1993-1999	----	----	1993-2002
3NO Females	1978-2004	1985-2002	----	1985-1999	1993-2002	----

Table 3.- American plaice data by sex from age-length key and 3NO Spanish Survey length distributions for the 1997 cohort (the age-length key was provided by Joanne Morgan).

	Females		**Males**	
Year/age	**Modal length from length distribution (cm)**	**Mean length at age from age-length key (cm)**	**Modal length from length distribution (cm)**	**Mean length at age from age-length key (cm)**
1999 / 2	10	11.05		
2000 / 3	16	16.23	16	15.47
2001 / 4	20	21.58	20	20.78
2002 / 5	24	27.62	24	23.99
2003 / 6	28	31.44	26	27.2
2004 / 7	32	34.84	28	29.9
2005 / 8	36	38.45	30	32.14
2006 / 9	38	39.76		33.27

Table 4.- Maximum lengths of American plaice by sex, year and zone from length distribution.

	3M		**3NO**	
Year	**Males**	**Females**	**Males**	**Females**
1995	48.5	60.5		
1996	48.5	60.5		
1997	48.5	58.5	50.5	68.5
1998	44.5	58.5	54.5	68.5
1999	44.5	60.5	48.5	76.5
2000	48.5	56.5	52.5	72.5
2001	46.5	58.5	56.5	70.5
2002	46.5	56.5	52.5	68.5
2003	48.5	58.5	46.5	66.5
2004	46.5	58.5	56.5	68.5
2005	48.5	58.5	52.5	68.5
2006	46.5	60.5	48.5	76.5

Table 5.- Mean and standard deviation of the maximum mean lengths at age of American plaice by sex and zone from age distribution.

	Surveys Sampling		
NAFO Division	**Males**	**Females**	**Sexes combined**
3NO L_{max}	50.58±4.47	69.63±3.81	60.10±10.58
3M L_{max}	42.04±1.87	53.29±1.91	47.66±6.04

Table 6.- Body growth rate, k, for all the studied cohorts, by sex and area

	3M		3NO	
Cohort	**Males**	**Females**	**Males**	**Females**
C02			0.203	0.026
C01			0.175	-0.017
C00			0.161	0.157
C99	0.746	0.369	0.099	-0.063
C98	0.809	0.23	0.22	0.143
C97	0.273	0.303	0.306	0.145
C96	0.156	0.127	0.145	0.131
C95	0.276	0.235	0.092	0.058
C94	0.249	0.198	0.034	0.088
C93	0.264	0.215	-0.009	0.1
C92	0.453	0.163		0.06
C91	0.371	0.15		0.015
C90	0.231	0.128		0.011
C89		0.018		0.004
C88		0.051		0.003
C87		0.166		-0.005
C86		0.073		-0.022
C85		0.213		-0.02
Mean $\pm$ SD(*)	0.38 $\pm$ 0.22	0.18 $\pm$ 0.09	0.16 $\pm$ 0.08	0.07 $\pm$ 0.06

(*)Mean and SD made only with the positive values of k

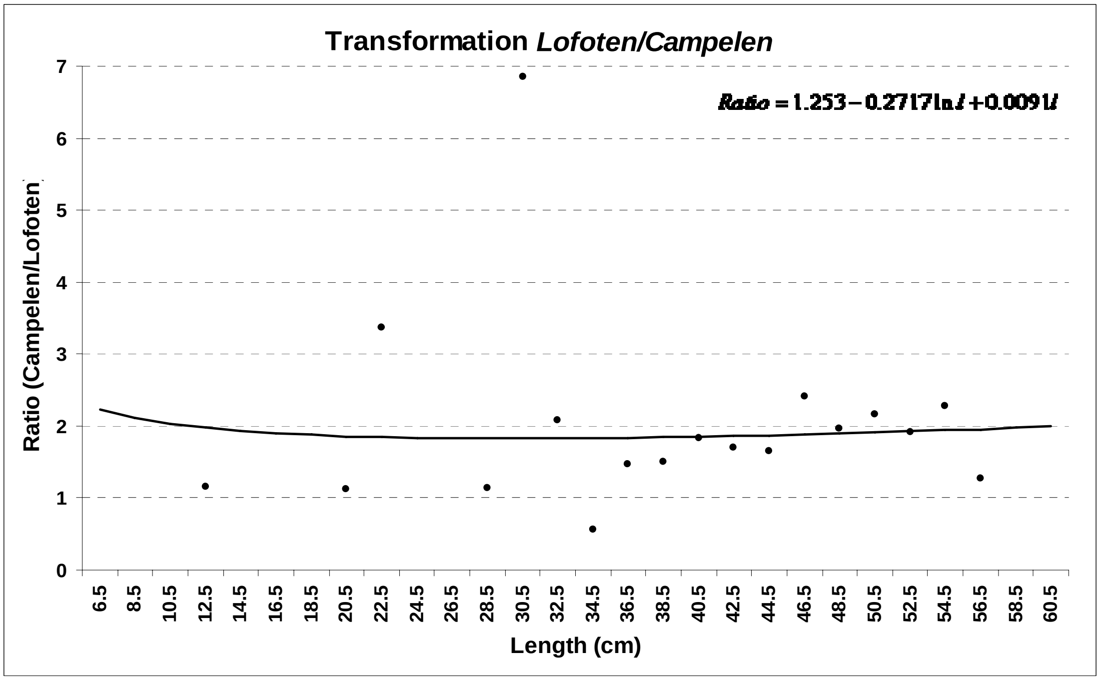
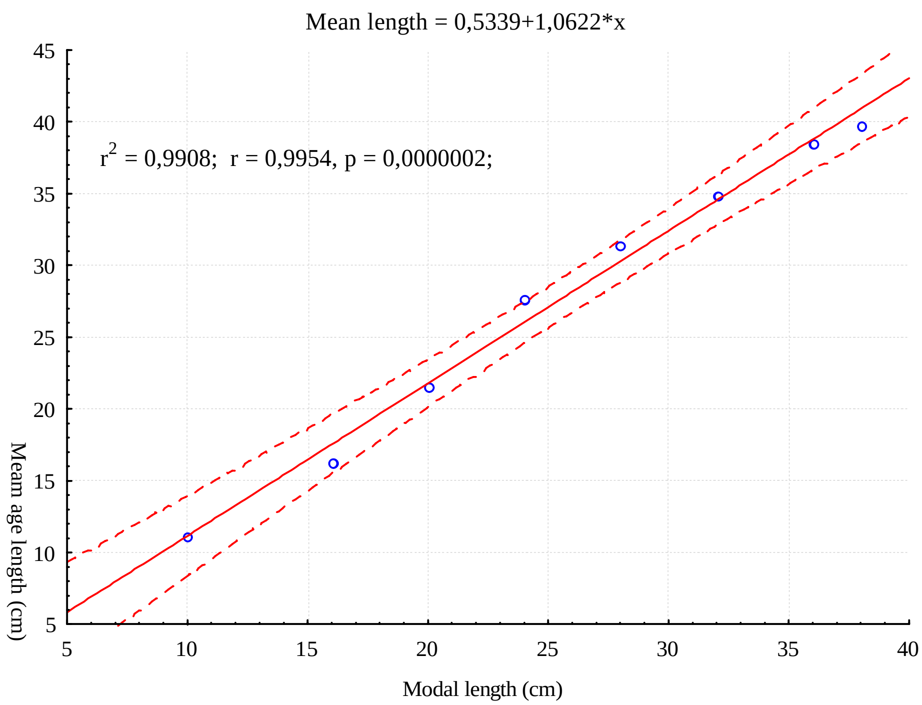
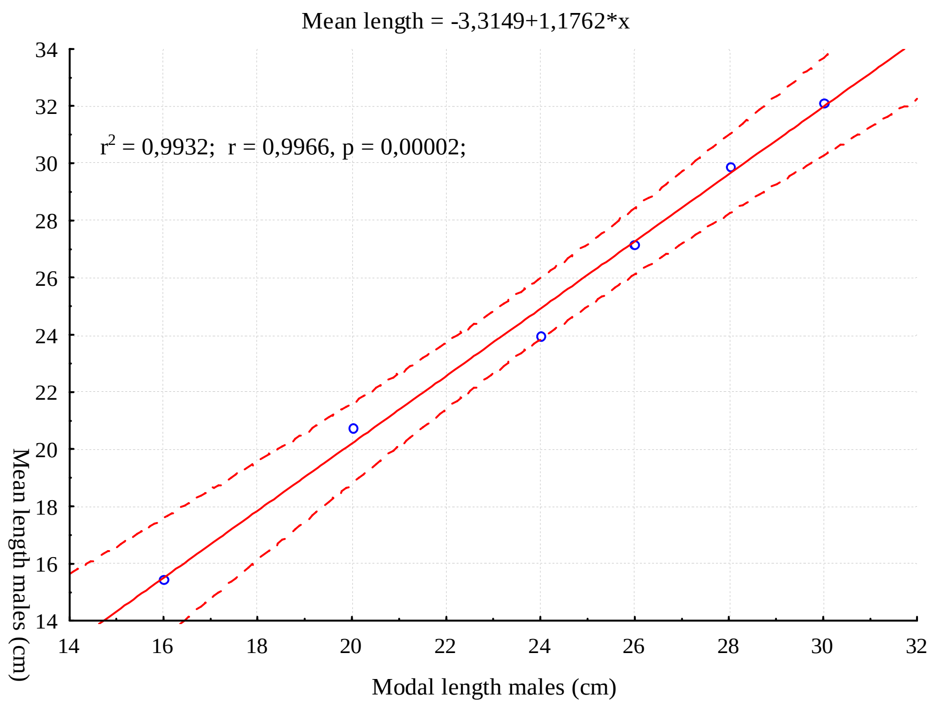


Figure 1. Results of the transformation *Lofoten* / *Campelen*



(n) Confidence level 99%

Figure 2.- American Plaice 3NO females. Mean length at age from age-length key (cm) *vs* modal length (cm) from 3NO Spanish survey length distribution. 1999-2006.



(n) Confidence level 99%

Figure 3.- American plaice 3NO males. Mean length at age from age-key length (cm) *vs* modal length (cm) from 3NO Spanish Survey length distributions. 2000-2005

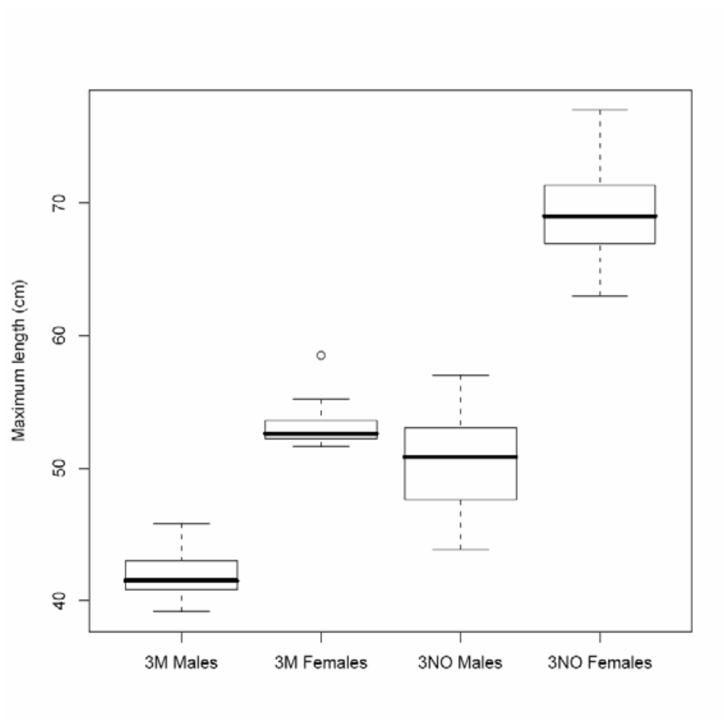


Figure 4.- American plaice maximum mean length at age (cm) by sex from 3NO (1997-2006) and 3M (1995-2006) survey data.

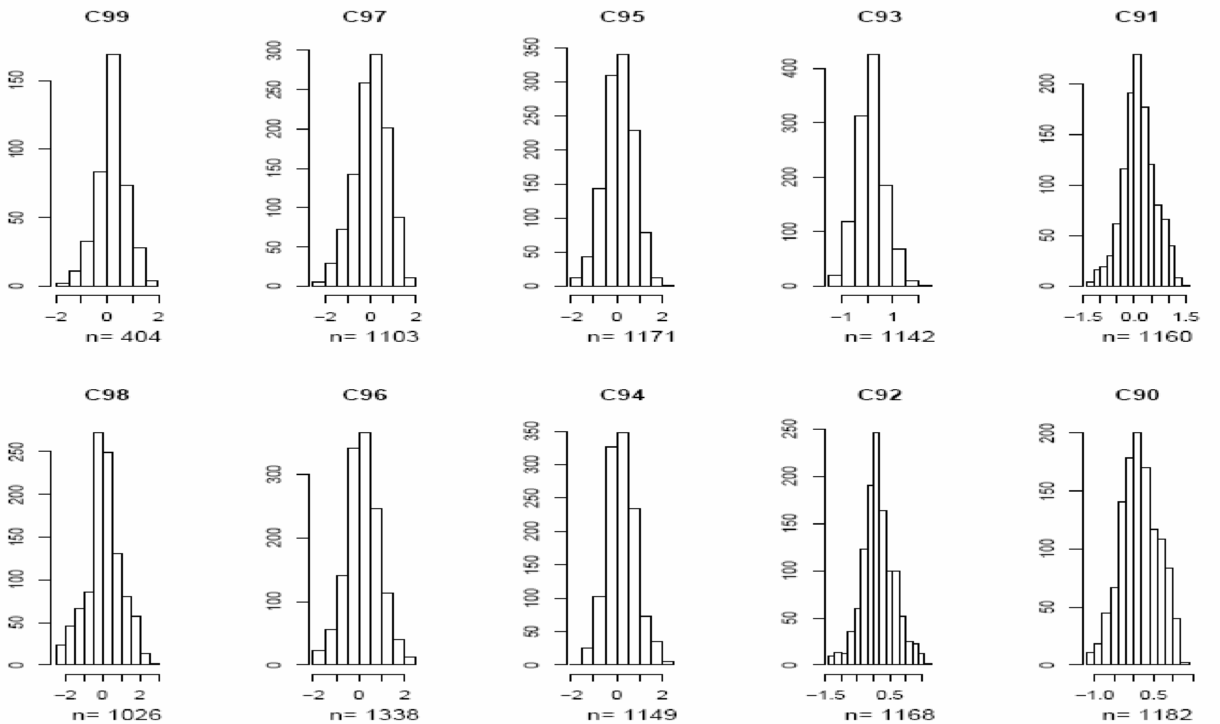


Figure 5a.- Histogram of the bootstrap of the growth parameter k for 3M males.

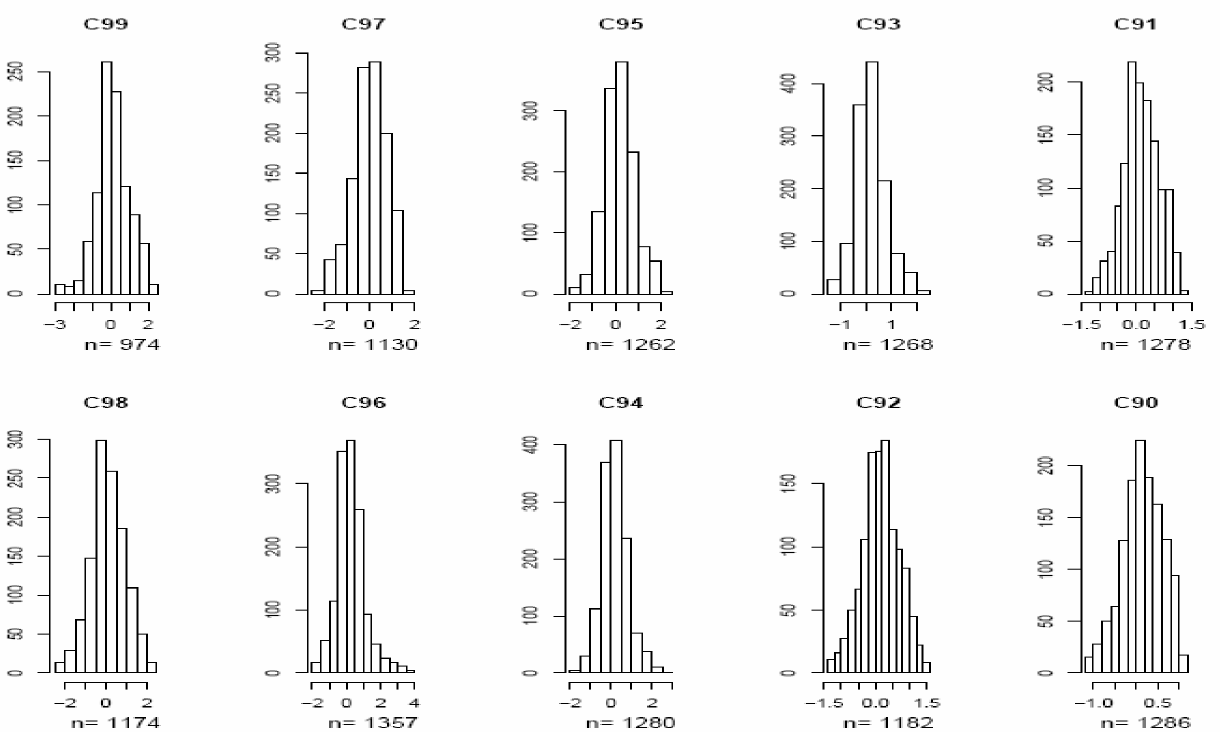


Figure 5b.- Histogram of the bootstrap of the growth parameter k for 3M females.

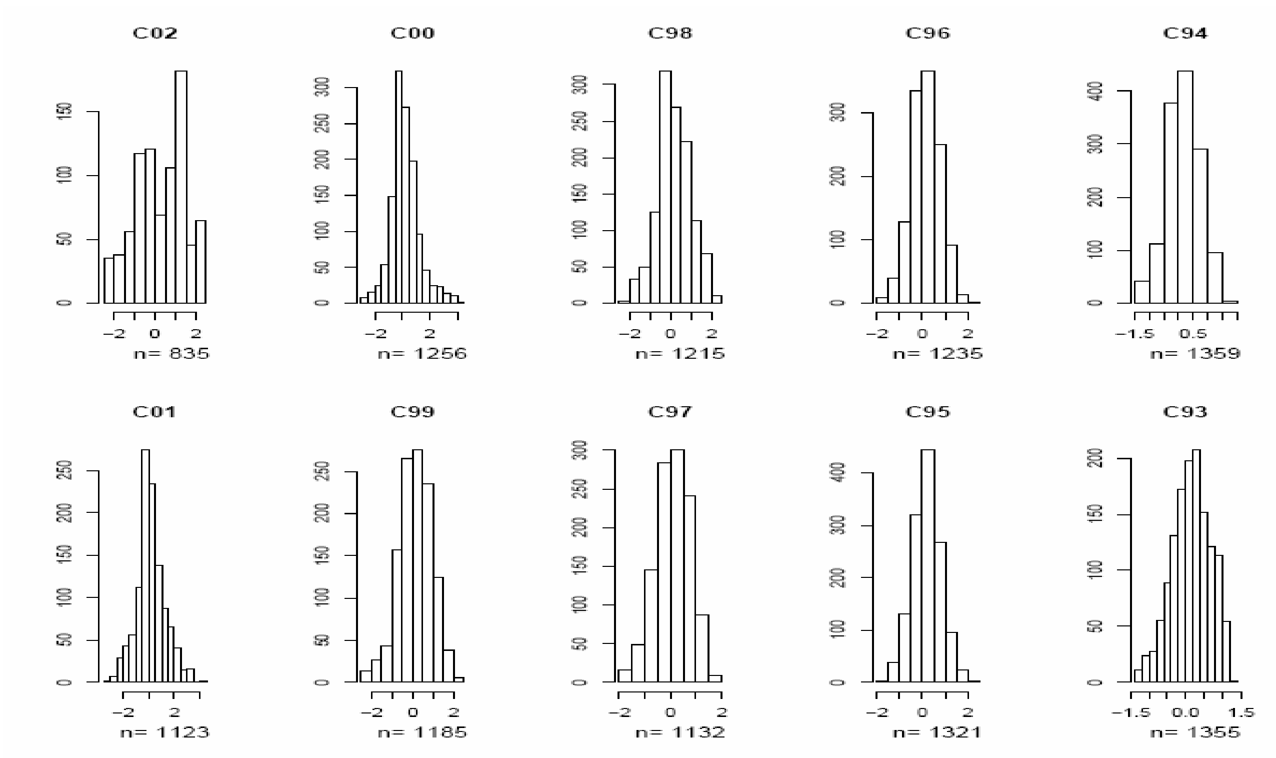


Figure 5c.- Histogram of the bootstrap of the growth parameter k for 3NO males.

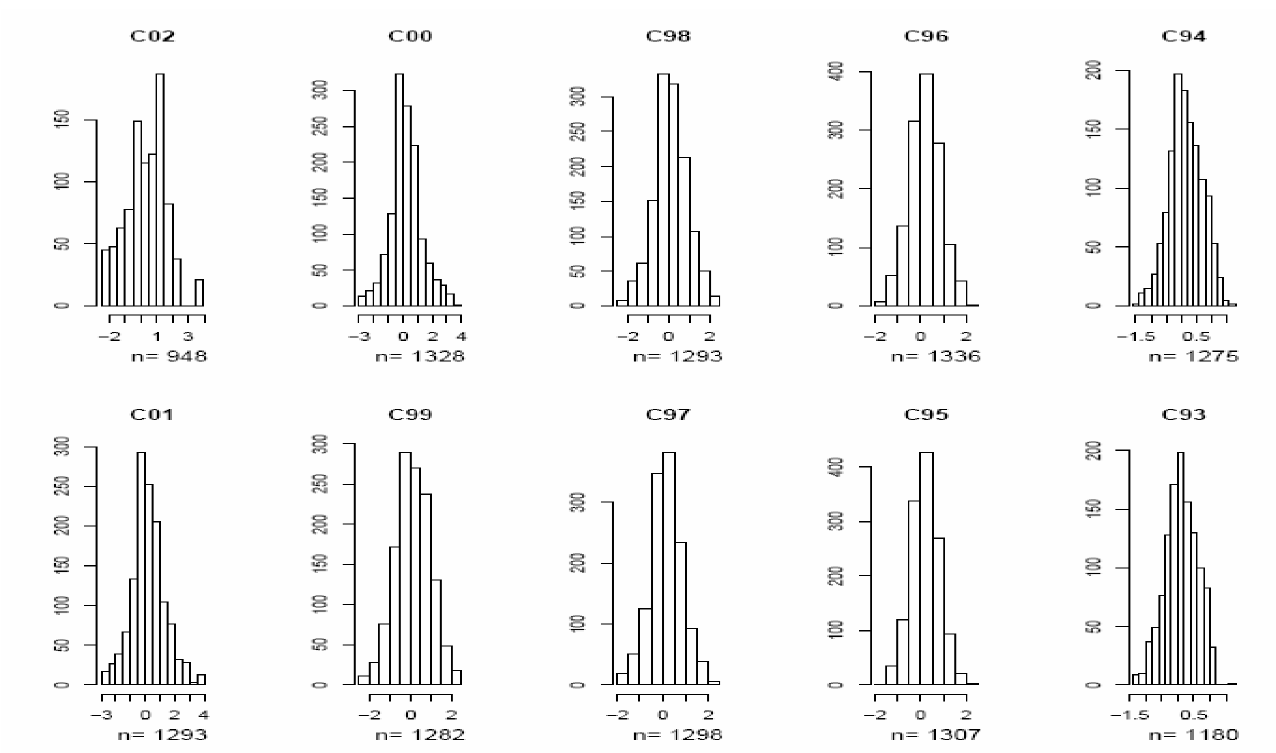


Figure 5d.- Histogram of the bootstrap of the growth parameter k for 3NO females.

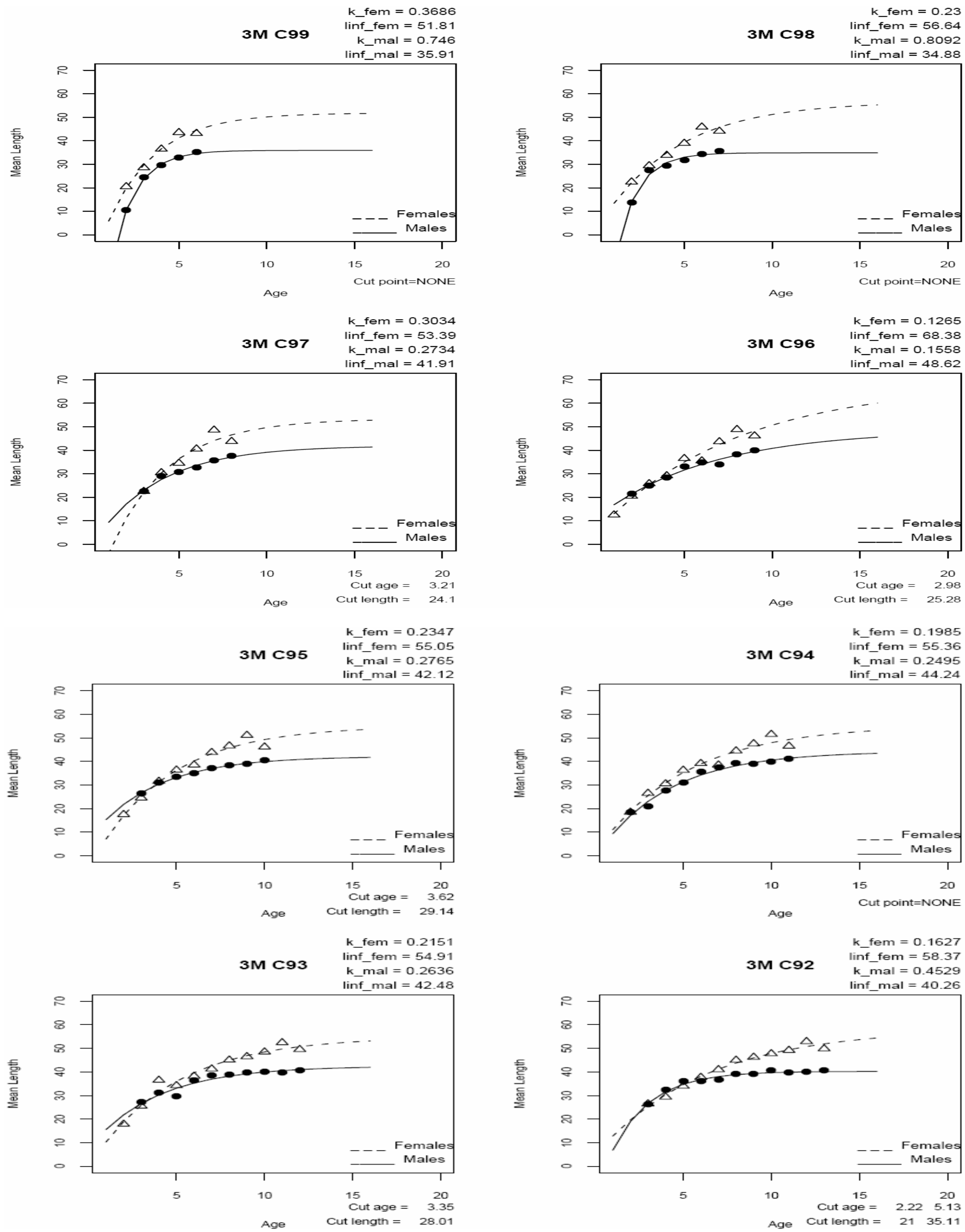


Figure 6a.- Results of the Von Bertalanffy curve comparison of the males and females in 3M.

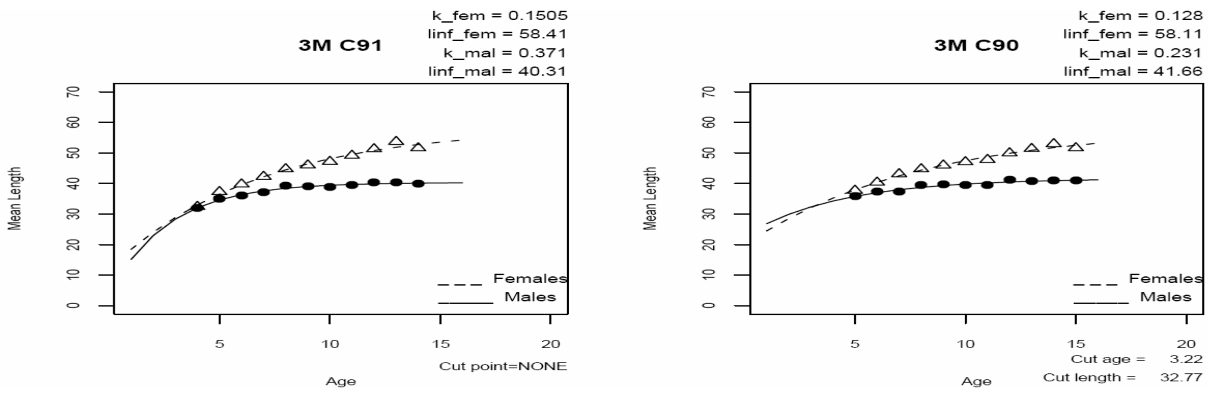


Figure 6a (cont.).- Results of the Von Bertalanffy curve comparison of the males and females in 3M.

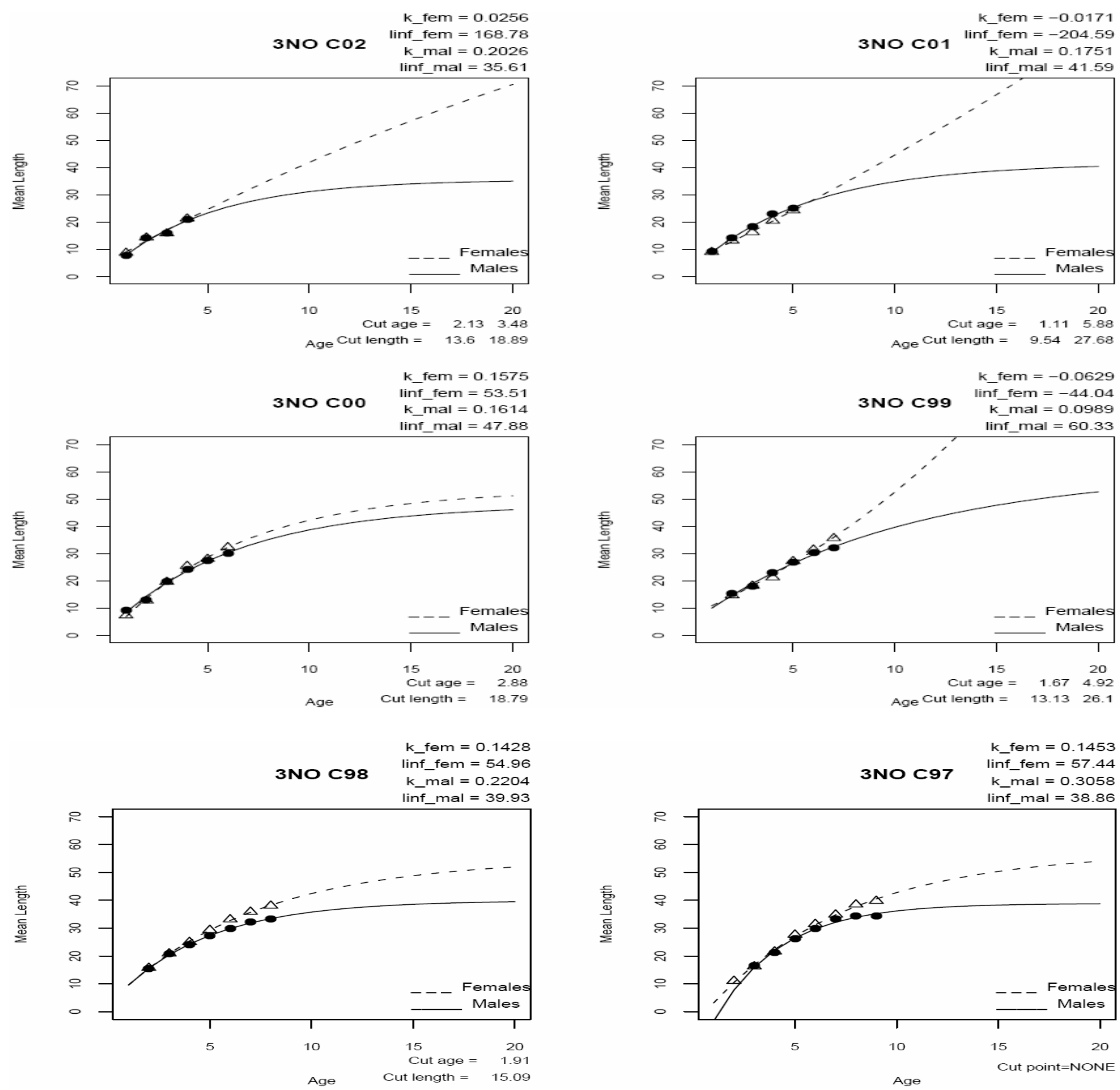


Figure 6b.- Results of the Von Bertalanffy curve comparison of the males and females in 3NO.

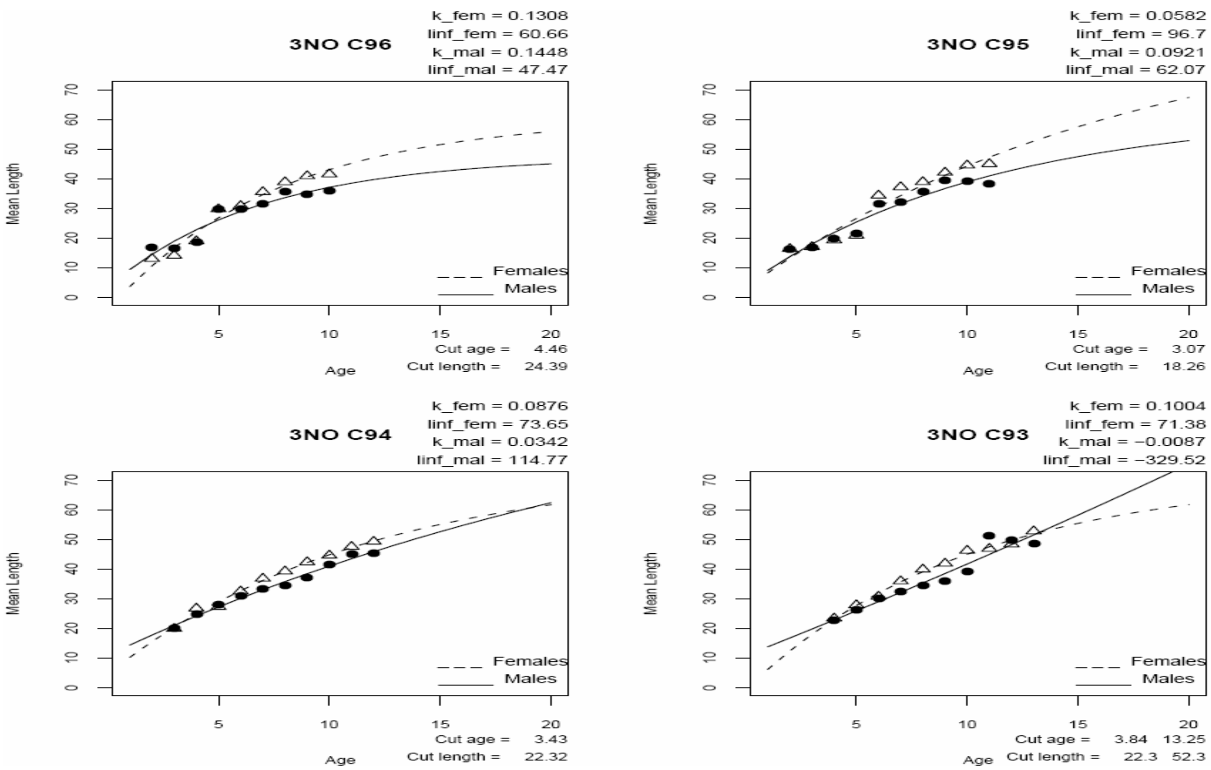


Figure 6b (cont).- Results of the Von Bertalanffy curve comparison of the males and females in 3NO.

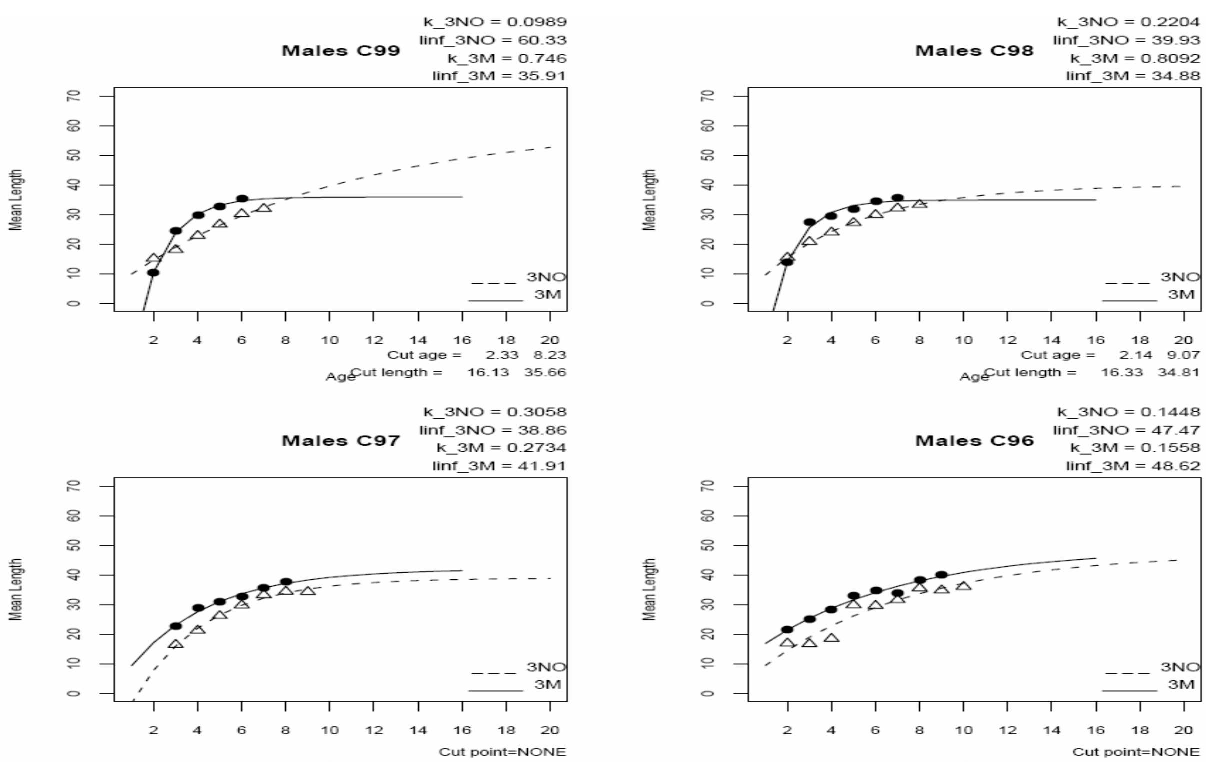


Figure 6c.- Results of the Von Bertalanffy curve comparison of the males of 3NO and 3M.

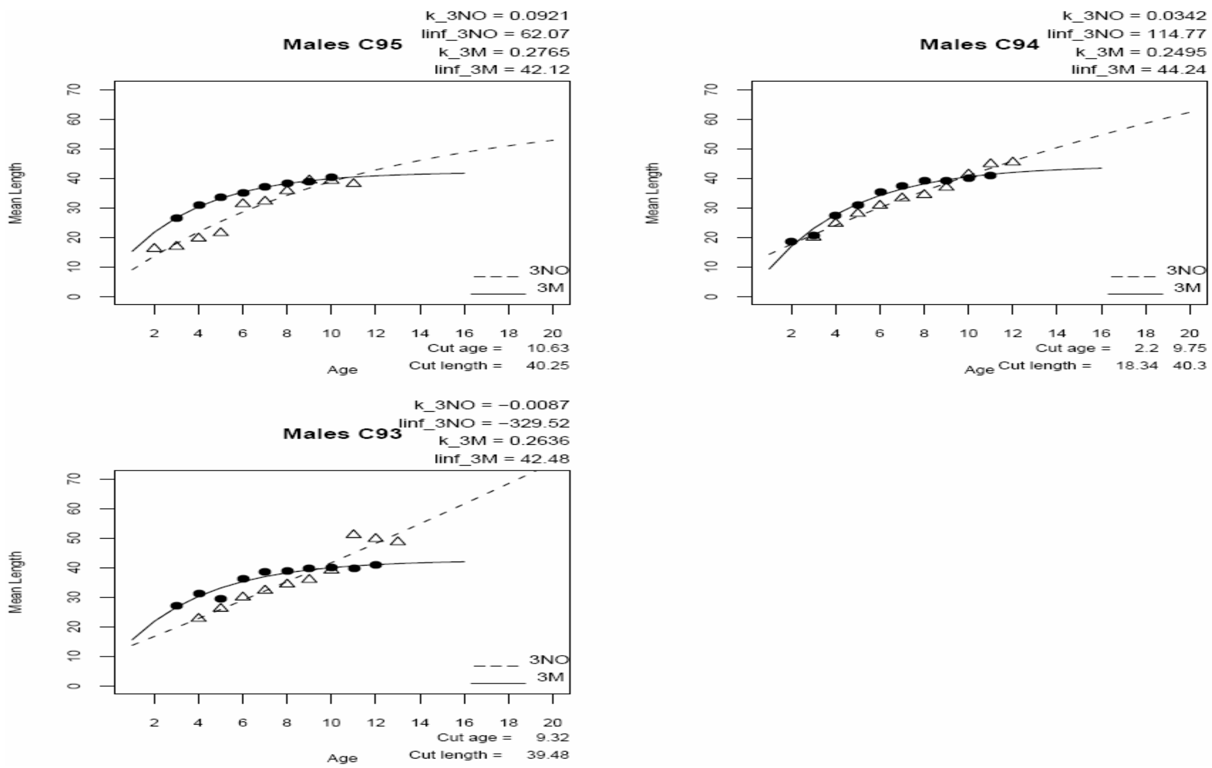


Figure 6c (cont.).- Results of the Von Bertalanffy curve comparison of the males of 3NO and 3M.

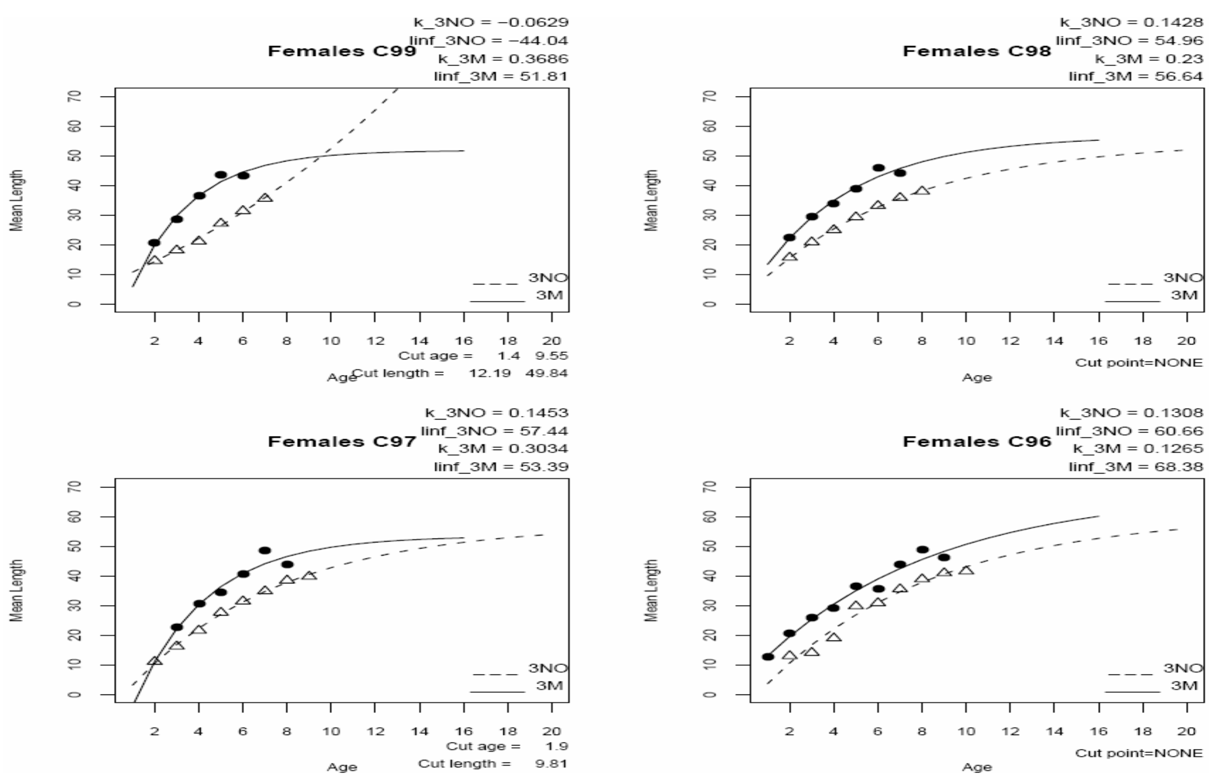


Figure 6d.- Results of the Von Bertalanffy curve comparison of the females of 3NO and 3M.

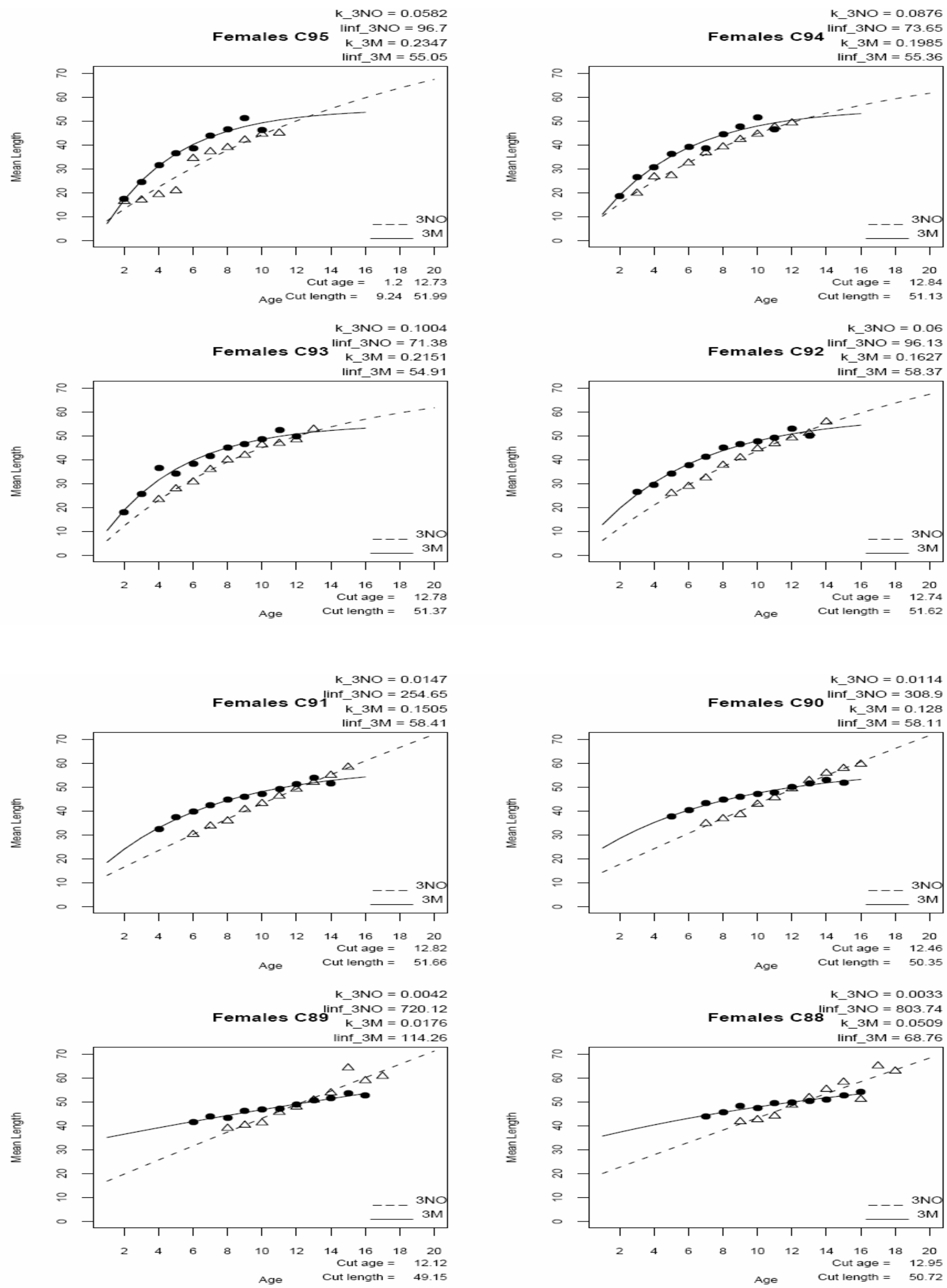


Figure 6d (cont.).- Results of the Von Bertalanffy curve comparison of the females of 3NO and 3M.

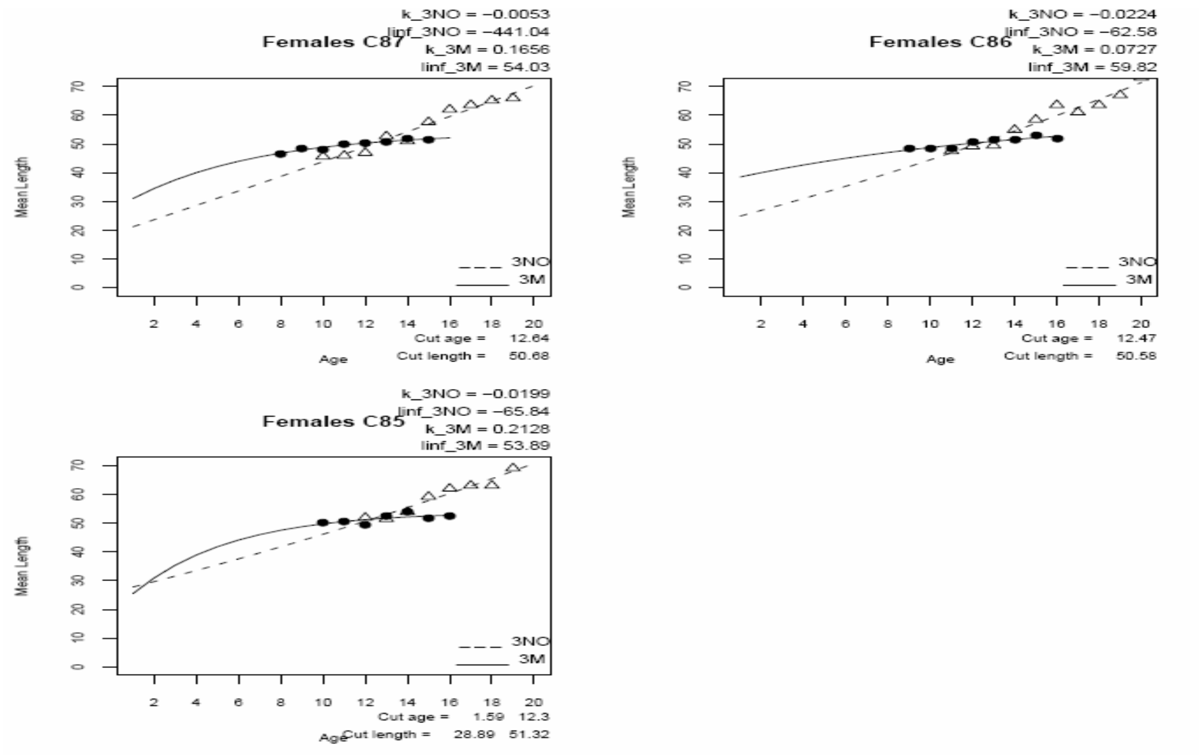


Figure 6d (cont.).- Results of the Von Bertalanffy curve comparison of the females of 3NO and 3M.