NEW INSIGHTS INTO FISH GROWTH PARAMETERS ESTIMATION BY MEANS OF LENGTH-BASED METHODS

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A tutte le donne
della mia famiglia

«… Ma chi glielo fa fare?»
«Mah… Soltanto lo spirito di servizio»
«Ha mai avuto dei momenti di scoramento, magari dei dubbi, delle tentazioni di abbandonare questa lotta?»
«No, mai!»

Intervista a Giovanni Falcone

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ABSTRACT

Growth studies are an essential instrument in the management of fisheries resources since they contribute to estimates of production, stock size, recruitment and mortality of fish populations. In the event that age becomes too complex to be established through an observation of hard parts (otoliths, scales, opercula, rays, spines and vertebrae), information about the demographic parameters of fish and other animal populations can be obtained by length-frequency analysis. Length-frequency distributions are commonly analyzed by means of histograms, although they present several problems, such as a dependency on the origin, width and number of class intervals, discontinuity of data and fixed bandwidth. This can largely affect the reliability of the estimates, i.e. the results become dependent upon the data massage operated by the user.

The main aim of this research study was an attempt to contribute to overcome some of the above-mentioned limits. Two algorithms were tested in terms of their capacity to produce accurate estimates of fish growth parameters. The first, the Birgé and Rozenholc algorithm, has recently been proposed for determining the optimal number of intervals to be used for building a regular histogram from available data. The second, the Expectation-Maximization (EM) algorithm, has become a popular tool in statistical computations involving incomplete data, or in similar problems, such as mixture estimation.

Monte-Carlo simulations of fish populations having different biological characteristics were generated to test the efficiency of these two algorithms. A Monte-Carlo procedure tests the ability of certain methods to describe the underlying structure of a simulated dataset, and thus makes it possible to predict the conditions under which a method will be successful or will fail in performing research studies concerning natural populations.

In this regard, two marine species were chosen as representatives of opposing life-histories: the Red mullet (*Mullus barbatus* Linnaeus, 1758), a fast-growing species, and the European hake (*Merluccius merluccius* (Linnaeus, 1758), a slow-growing species. A length sample of size n = 100,000 was generated for each species. In order to evaluate the performance of the Birgé and Rozenholc algorithm using samples of different sizes, 100 random datasets containing 100, 200, 500 and 1000 length measurements respectively were extracted from each hypothetical population. Data for each of these 800 length datasets was then partitioned using (i) the method proposed by Birgé and Rozenholc and (ii) the classical interval widths (1 cm for the Red mullet and 2 cm for the European hake).

These simulated length-frequency distributions were then analyzed by means of two length-frequency methods: (i) the ELEFAN I method, a non-parametric approach, and (ii) Bhattacharya's method, a parametric approach. For the present study, a Scilab 4.0 version of the ELEFAN I and the Bhattacharya methods was developed. Since the EM algorithm functions best with samples of size $n \geq 1000$, only the 100 random datasets each containing 1000 length measurements were used to run the algorithm. Two length datasets were also used to test the performance of the two algorithms on field data.

The results obtained using the two algorithms were very encouraging. The Birgé and Rozenholc algorithm proved to be an easy and efficient method for choosing the number of intervals in a histogram. On the other hand, the efficiency of the EM algorithm became evident for the two species considered both with simulated and real length data.

In conclusion, the results obtained using the two algorithms seem to be of great interest and their methodological and theoretical contribution to this field could represent a landmark in the enhancement of stock assessment studies.

1. INTRODUCTION

Information about fish age, development and growth is a cornerstone in fishery research and management. By development we mean the sequencing of life-history stages while growth is a measure of size change of the whole body or some body part; growth rate is also a measure of size change as a function of time. Growth depends upon the quantity and quality of food ingested, with inadequate nutrition delaying both growth and developmental transitions, such as the timing of onset of sexual maturation. When food is limited the onset of maturation may be delayed for months or years until good feeding conditions arise. In other words, the timing of sexual maturation appears to be more closely associated with size than age, leading to the concept that maturation is achieved once a “critical size” has been reached. Furthermore, during adulthood, fecundity or gamete production may be related to body size, and alterations in nutrition can lead to either depression or enhancement of the reproduction.

Thus food availability, size increase, accumulation of energy reserves and timing of sexual maturation and reproduction are closely linked. These factors, in turn, relate to production, that is determined by the reproduction and growth rates of individuals within the population and by their mortality rate. These functional rates determine the population dynamics over time, as well as the structural elements of the population, such as biomass, density and size-frequency distribution, at any point in time. As such, information about age and growth is extremely important in almost every aspect of fisheries (Jobling, 2002).

Organisms grow because greater body size confers a number of advantages that can ultimately result in higher lifetime reproductive output. Larger individuals are subjected to lower predation mortality: the faster they grow the more rapidly their mortality rate decreases. Larger individuals can also store more energy and thus become less susceptible to fluctuations in food supply and environmental extremes. Fecundity and ability to compete for mates and resources also increase with size. Large size can be attained by hatching at a large size, growing fast or growing for a long time. Furthermore, delaying the age at maturity provides more energy for growth (Jennings *et al.*, 2001).

1.1. Growth models and equations

Growth equations are used to describe changes in the length or weight of a fish with respect to time, although the constants derived from such empirical equations may have no exact biological meaning. Numerical expression of growth may be based on absolute changes in length or weight (**absolute growth**), or changes in length or weight relative to the fish size (**relative growth**). Length almost always increases with time, whereas weight can either increase or decrease over a given time interval depending upon the influence of the various factors that affect the deposition and mobilization of body materials.

Measurements of growth in relation to time provide an expression of growth rate. Growth in length can usually be modelled by using an asymptotic curve which tapers off with increasing age. Growth in weight is usually sigmoidal, i.e. the weight increment increases gradually up to an inflection point from where it gradually decreases. Thus, growth rates are constantly changing, and the absolute growth increments will be different for different sizes of fish (Jobling, 2002).

A number of mathematical functions have been used to describe growth curves, including the Gompertz, the logistic, and a range of straight-line and exponential approximations (Beverton and Holt, 1957; Ricker, 1979; Weatherley and Gill, 1987; Prein *et al.*, 1993; Elliott, 1994). Among all the models, the **von Bertalanffy growth function** (VBGF) (Fig. 1.1) is the most frequently used to describe growth in fishes, and in many other marine organisms, because the constants can be readily incorporated into early stock assessment models. The function was derived by considering growth as the balance between anabolic and catabolic processes in an organism (von Bertalanffy, 1934, 1938, 1957; Pauly, 1980).

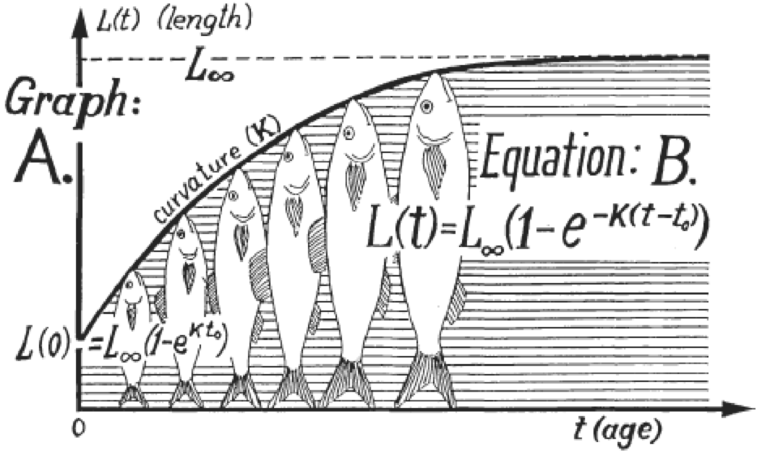

Fig. 1.1 The von Bertalanffy growth equation (Diagram taken from Sparre and Venema, 1998).

The simplest derivation of the VBGF is:

$$\delta L/\delta t = k(L_\infty - L) \qquad (1)$$

where L is length, t is time, $\boldsymbol{L_\infty}$ is the asymptotic length of the fish, that is the maximum length to which a fish would grow on average if it lived to be very old age, and $\boldsymbol{k}$ is the Brody growth, a growth constant expressing the rate at which length approaches the asymptote (Gulland, 1969; Ricker, 1979).

Note that L_∞ is not necessarily the same as the maximum fish length in a sample; if the fish mortality rate is very high, or the fishing gear only takes smaller fish, then the maximum length in a length-frequency sample may be considerably smaller than L_∞. On the other hand, if many old fish are present in the sample, L_∞ may be smaller than the length of the largest fish, because individual variability will ensure that some fish grow up to a larger than average maximum length and others to a smaller one. The parameter L_∞ is meant to describe the average growth of the whole fish population.

The parameter k could be considered as a measure of the fish growth rate; however, it does not correspond to the expected increase in length per unit time. In the limit, this is actually given by

$$k\left(1-\frac{L(t)}{L_\infty}\right) \qquad (2)$$

so that for a given value of k, the growth rate declines over time as fish length approaches L_∞. Nevertheless, the larger k is, the faster the fish grows towards L_∞.

Whereas L_∞ has a straightforward interpretation, that of k is more complex because it describe the instantaneous growth rate ($\delta L/\delta t$) relative to the difference between L_∞ and the fish length at a given time. Integration of the VBGF gives:

$$L_t = L_\infty(1-e^{-k(t-t_0)}) \qquad (3)$$

where L_t is the length-at-age t and t_0 is the theoretical age of the fish at zero size under the assumption that the von Bertalanffy growth curve describes growth accurately right down to zero length. Even if this unlikely assumption is true, fish will be born with some positive length, so t_0 will usually be negative.

The equation (3), commonly called the non-seasonal von Bertalanffy growth function (Fig. 1.2), provides a perfectly adequate description of growth for many species.

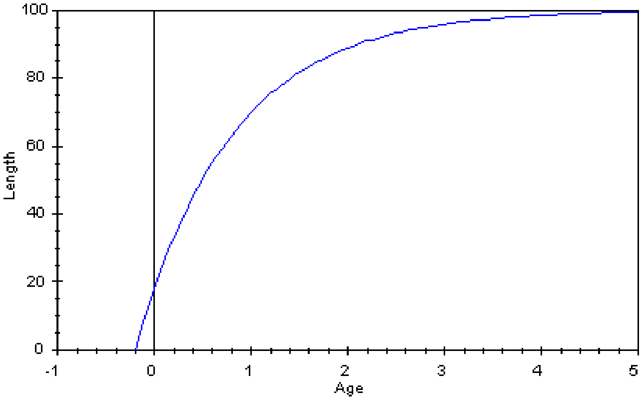

Fig. 1.2 A non-seasonal von Bertalanffy growth curve with parameters L_∞ = 100, k = 1.0 and t_0 = -0.2 (Diagram taken from Kirkwood *et al.*, 2001).

In some species (particularly those found in tropical waters) there is clear evidence that growth rate can vary with the seasons. In these species, growth is normally fast in summer when water temperature is high and slow in winter when water is cold. Some species may even cease growing entirely over winter. For species showing clear seasonal growth, the non-seasonal von Bertalanffy growth curve will not be sufficient to describe growth accurately (especially for relatively short-lived species).

The most frequently used seasonal version of the von Bertalanffy growth curve was originally proposed by Hoenig and Choudary Hanumara (1982). This allows sinusoidal variation in growth rates throughout the year according to the formulation:

$$L(t) = L_\infty\left[1 - e^{-\left[k(t-t_0)+S\sin 2\pi(t-t_s)-S\sin 2\pi(t_0-t_s)\right]}\right] \qquad (4)$$

where

$$S = \frac{Ck}{2\pi} \qquad (5)$$

This equation has two parameters in addition to the usual non-seasonal von Bertalanffy growth curve (L_∞, k and t_0). The first, C, measures the relative amplitude of seasonal oscillations in growth rate. When $C = 0$, growth is non-seasonal, while when $C = 1$ the seasonality is sufficiently large so that growth ceases for just an instant during the year. Values of C greater than 1 correspond to shrinkage in length at some stage of the year. The second parameter, t_s, describes the phase of seasonal oscillations. With $-0.5 < t_s < 0.5$, t_s denotes the time of the year corresponding to the start of the convex segment of sinusoidal oscillation. That is equivalent to say that $t_s + ½$ is the time of the year when the growth rate is slowest, i.e. equivalent to the "winter point". It is to ensure that winter point can vary from the start to the end of the current year that leads to the stated range for t_s.

Figure 1.3 shows a Hoenig and Choudary Hanumara seasonal growth curve with parameters $L_\infty = 100$, $k = 1.0$, $t_0 = -0.2$, $C = 0.8$ and $t_s = -0.3$. Note that, with C near 1, growth rate varies noticeably during the year, but it never actually ceases at any time. The growth rate is slowest each year at the winter point, which occurs 0.2 (= -0.3 + 0.5) time units from the beginning of each year.

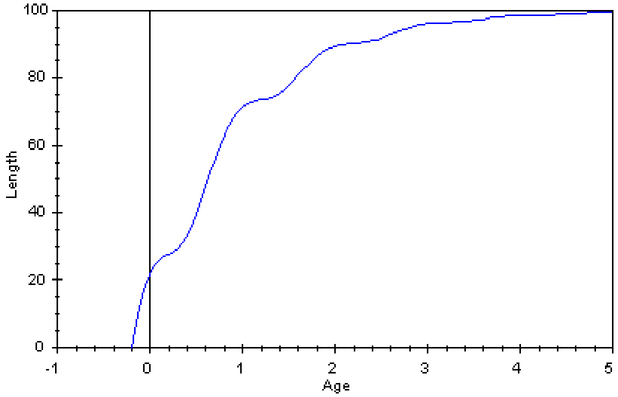

Fig. 1.3 A Hoenig and Choudary Hanumara seasonal growth curve with parameters L_∞ = 100, k = 1.0, t_0 = -0.2, C = 0.8 and t_s = -0.3 (Diagram taken from Kirkwood *et al.*, 2001).

Although negative growth (shrinkage) has actually been observed for some species, this is the exception rather than the rule, and in most cases negative growth is highly unlikely. Instead, for species exhibiting marked seasonal variation of growth rate, it is more likely that there may be a period during the year when growth ceases.

A model incorporating this phenomenon was proposed by Pauly *et al.* (1992). In this model,

$$L_t = L_\infty(1 - e^{-q}) \tag{6}$$

where

$$q = k(t' - t_0) + \frac{k}{Q}\left[\sin Q(t' - t_s)\right] - \frac{k}{Q}\left[\sin Q(t_0 - t_s)\right] \tag{7}$$

and

$$Q = \frac{2\pi}{(1 - NGT)} \tag{8}$$

The Pauly *et al.* curve has six parameters: the usual non-seasonal parameters (L_∞, k and t_0), and three others. The first of these, t_s, has essentially the same meaning as in the Hoenig and Choudary Hanumara growth curve. It now, however, needs to be understood to imply that the middle of the period of no-growth during a year occurs at time t_s+½ from the start of the year. The second parameter, usually written *NGT* (standing for *No Growth Time*), measures the length of the time period when no growth occurs. Thus, there is no growth between the times t_s+½ - ½*NGT* and t_s+½ + ½*NGT*. For the rest of the time, when fish is growing, it follows a Hoenig and Choudary Hanumara growth curve with the same values of L_∞, k, t_0 and t_s, but with $C = 1$. The third additional parameter, t', is described by Pauly *et al.* (1992) as being obtained "by subtracting from the real age t the total no-growth time occurring up to time t".

Figure 1.4 shows a Pauly *et al.* seasonal growth curve with parameters L_∞ = 100, k = 1.0, t_0 = -0.2, t_s = -0.3 and *NGT* = 0.5. Please note that growth ceases between times -0.05 and 0.45 (-0.3 + 0.5 ± 0.5/2) each year. Noteworthy that the overall rate at which the maximum length is approached is rather little for this growth curve than for the other two (despite the fact that all the other parameters have the same values). This is because growth ceases for half of each year.

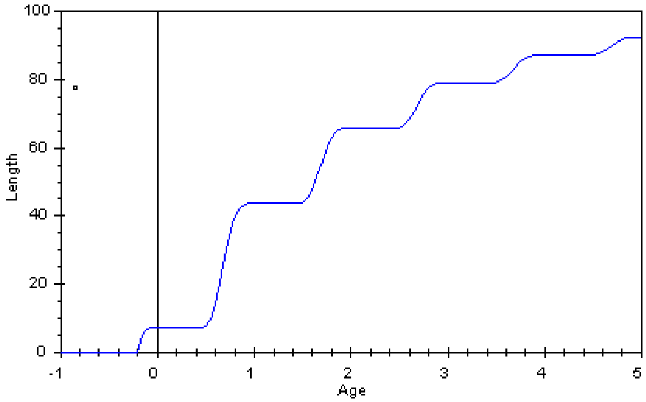

Fig. 1.4 A Pauly *et al.* seasonal growth curve with parameters L_∞ = 100, k = 1.0, t_0 = -0.2, t_s = -0.3 and *NGT* = 0.5 (Diagram taken from Kirkwood *et al.*, 2001).

The deterministic nature of the von Bertalanffy equation is the primary problem when individual variability in growth exists, each fish in a group being considered to grow according to the model, but with its own L_∞ and k (Isaac, 1990).

Individual variability is probably the most arguable point in fitting the VBGF to average values, since one should expect that individual variability of the growth parameters is a general feature of natural populations. Every individual organism is a unique result of heredity and environment, so that no two organisms in a population will grow at precisely the same rate and attain the same size at a given age (DeAngelis and Mattice, 1979).

In addition, some authors have shown that if a deterministic age-length-key is used to determine the age frequency of catches on the basis of length data, biased results are to be expected (Kimura, 1977; Westrheim and Ricker, 1978).

Bartoo and Parker (1983) incorporated a stochastic element in von Bertalanffy's relationship to improve this approach. Sainsbury (1980) developed a stochastic version of the VBGF for size increment data, stating that k is underestimated when data obtained from populations with different individual growth parameters are analyzed with the classical deterministic equation. Finally, Schnute (1981) developed a new growth model, which includes von Bertalanffy's, Gompertz's and other models as special cases, and in which an error component for the size-at-age is incorporated.

Differences in growth patterns, caused by intrinsic or extrinsic factors, between different populations or for different time periods, are extensively reported (e.g. Bannister, 1978; Craig, 1978; Anthony and Waring, 1980; Molloy, 1984). On average, these differences reflect modifications in the budget of catabolism and anabolism, and are expressed by the parameters L_∞ (or W_∞) and k (Beverton and Holt, 1957).

The parameter L_∞ of the VBGF is proportional to the ratio of anabolism and catabolism, and the parameter k is proportional to the coefficient of catabolism. Thus, factors affecting the food consumption rate should produce changes in the coefficient of anabolism and therefore in L_∞. Other differences in general metabolic activity should affect the rate of catabolism to a greater extent and therefore the parameter *k* (Beverton and Holt, 1957).

It is reasonable to suppose that the differences between the individuals of a given population, living under similar external conditions, should mostly be caused by genetic factors and affect the general metabolic activity of the organism, and probably indirectly both L_∞ and *k*. The proportion of the variability of each parameter may differ according to the species, but a preliminary investigation conducted by Isaac (1990) suggests that *k* varies more strongly than L_∞.

In many fish the variance of length-at-age increases with increasing age (see e.g. Steinmetz, 1974; Westrheim and Ricker, 1978). This led some authors to suppose that L_∞ constitutes the major source of variation between individuals (Jones, 1987; Rosenberg and Beddington, 1987). However, in other fish (mostly pelagic and fast-growing species) and in many molluscs, variance in length-at-age first increases and then decreased (Wolf and Daugherty, 1961; Feare, 1970; Poore, 1972; Bartoo and Parker, 1983), suggesting that it is the variance of *k* which is high. Moreover, it could also be argued that bias in the determination of age or sampling errors are the cause of such data patterns. Natural variability and sampling bias obviously produce a combined effect in the data, and therefore, further investigation is needed to clarify their contribution, separately (Isaac, 1990).

The parameters of the von Bertalanffy growth equation are widely used to describe fish life histories. Across species there are close relationships between these parameters and those describing other aspects of the life history, such as age and size at maturity. In general, high *k* is associated with young age and small size at maturity, high reproduction output, short life span and low asymptotic length. Conversely, species with low *k* have older age and bigger size at maturity, lower reproductive output, longer life spans and greater asymptotic length (Jennings *et al.*, 2001). The relationships are consistent with trade-offs, such that change in a single trait which may increase lifetime reproductive success is countered by a corresponding decrease in fitness resulting from compensatory changes in other traits (Roff, 1984, 1992; Stearns and Crandall, 1984; Stearns, 1992). The resulting balance between traits is expected to maximize lifetime reproductive output. The result of compensatory trade-offs is that while fish exhibit many life histories, the parameters that describe life histories are consistently related (Beverton and Holt, 1959; Beverton, 1963, 1987, 1992; Charnov, 1993). These relationships have practical value because relatively simple measures of life history, such growth rate and age at maturity, can be used as surrogates for parameters such natural mortality which are needed in studies of population dynamics but are much harder to measure (Jennings *et al.*, 2001).

The relationship between life-history parameters suggests that the evolution of fish is governed by some very general features of life-history trade-offs (Charnov, 1993). These features may result from the evolutionary advantage of completing as much potential growth as possible within a life span that is constrained by the forcing effects of temperature on metabolic processes and growth (Beverton, 1963). Thus, age at maturity and reproductive output would be adjusted to life span and lifetime reproductive output would be maximized. Deferred maturity increases reproductive value at maturity because reproductive output increases with size and age. However, fish consistently mature at 65-80% of the maximum size they can attain (Beverton and Holt, 1959; Beverton, 1963). At this size, the costs of delaying maturity (risk of mortality) exceed those of slower growth that results from allocating resources to reproduction (Jennings *et al.*, 2001).

1.2. Estimating growth parameters

The estimation of growth curve parameters holds a central position in the fish stock assessment process (Pauly *et al.*, 1984; Rosenberg and Beddington, 1988) and may be based either on the absolute or relative age of the individual fish or else may be derived from length-frequency data analysis.

Ageing fish through the identification of periodic marks on hard structures (otoliths, scales, opercula, rays, spines and vertebrae) and tagging experiments are expensive and time-consuming procedures. In many aquatic animals (e.g., squids, crustaceans, shrimps and various tropical fishes) age determination is very difficult or even impossible.

The above mentioned disadvantages of age-based methods have led to the development, especially in the 1980s, of new methods for analysis of length data for growth and stock assessment. Length data can be collected rather cheaply and generally do not require specialized staff (Isaac, 1990). Moreover, many biological and fishery processes, e.g. fecundity, predation, selection by gear, etc., are better correlated with size (length or weight) than with age. Many characteristics of marine ecosystems are, broadly speaking, functions of the size of the organisms (Caddy and Sharp, 1986). Thus, there are good theoretical justifications for preferring length-based over age-based methods (Gulland, 1987; Pauly, 1987).

There are four approaches or methods to estimate growth curve parameters, each with its particular advantages: direct methods, back-calculation, analysis of length-at-age data and analysis of length-frequency data (also called length- or size-based methods).

1.2.1. Direct methods

The most accurate method for collecting age, hence growth, data is direct observation of individuals, but this is time-consuming and costly. However, under some circumstances it may be the only way in which reliable age and growth information can be obtained.

The method involves the release of marked fish into natural systems. Marked fish may be either hatchery-reared fish of known age or fish captured and marked *in situ*. The marked fish are later recaptured. The period of time between release and recapture is quantified and combined with data relating to changes in body size for use in growth models (Jobling, 2002). Data collected using the mark-and-recapture method can also be used to gain insights into the size of the fish population, provided that certain assumptions are met (Youngs and Robson, 1978; Guy *et al.*, 1996). One prerequisite of the method is that the released fish can be easily recognized at the time of recapture. In other words, the mark applied must be distinct and, if not permanent, at least long-lasting. Furthermore, if data from marked fish are to be of value in the estimation of growth rates and population sizes, the marks applied should not influence either growth or vulnerability of fish to predators, i.e. mortality rates should not be affected (Jobling, 2002).

Several marking and tagging techniques are available (Laird and Scott, 1978; Guy *et al.*, 1996, Campana, 2001). Fish may be marked by fin mutilation, hot and cold branding or tattooing; marks may also be applied to the fish via subcutaneous injections of dyes, liquid latex or fluorescent materials. There are also many types of tags such as the anchor tag and the plastic flag tag, which are applied externally, or as visible implant tags, coded wire tags and passive integrated transponders (PIT tags), which are subcutaneous or internal. The advantage of tags over other marking techniques is that tags can be numbered serially, allowing for individual recognition. Chemical marks may be induced in the body tissues by feeding, injecting or immersing the fish in solutions of a chemical that is taken up and incorporated into the tissue in question. The hard calcified tissues, such as scales, otoliths and skeletal elements, are the most common tissues used because they incorporate certain chemicals permanently and in a form that can provide a "time mark". Examples of chemical markers include fluorescent compounds such tetracycline and calcein, and metallic elements such us strontium and rare earth elements. Chemical marking techniques are particularly valuable in validation studies designed to cross-check fish age as determined by other methods (Weatherley and Gill, 1987; Brown and Gruber, 1988; Casselman, 1990; Rijnsdorp *et al.*, 1990; Devries and Frie, 1996; reviewed by Campana, 2001).

1.2.2. Back-calculation

When the scales and other hard parts increase in size in proportion to the fish size, they may not only be used in age determination but can also be considered to represent a diary recording of fish growth history. Thus, using knowledge about the relationship between size of the hard part and fish length, it may be possible to back-calculate the fish length at a given age by examination of the positioning of the various growth rings (Bagenal and Tesch, 1978; Weatherley and Gill, 1987; Devries and Frie, 1996). The data required for back-calculation are the fish length at capture, the radius of the hard part at capture (measured from the *nucleus* to the margin), and the *radius* of the hard part to the outer edge of each of the growth rings (either *annuli* or daily increment rings). Back-calculation of length at any given age is then usually carried out by one of four methods: the direct proportion method, the Fraser-Lee method, various curve-fitting procedures or the Weisberg method (Bagenal and Tesch, 1978; Devries and Frie, 1996). The choice of the method depends upon the type of relationship between the fish length and the dimensions of the hard part used in the back-calculation procedure.

The **direct proportion method** can be used when the relationship between body length and hard-part radius is linear and has an intercept that does not differ from the origin: in this case the growth of the hard part is directly proportional to the growth in length of the fish. The **Fraser-Lee method** is applicable when the intercept of the relationship between fish length and hard-part radius in not at the origin. Under these circumstances, length at time *t* (L_t) can be back-calculated using the formula:

$$L_t = \left[(L_c - a) / R_c \right] R_t + a \tag{9}$$

where L_c is the fish length at the time of capture, R_c is the radius of the hard part at capture, R_t is the radius of the hard part at time t, and a is the intercept of the regression line relating hard-part radius to fish length (Bagenal and Tesch, 1978; Devries and Frie, 1996). Sometimes, the use of simple linear regression may be precluded due to a lack of linearity between the dimensions of the hard parts and the body, or because there are different body length to hard part relations among age groups. Under such circumstances various **curve-fitting procedures** and covariance analysis may be used to address the problems (Bagenal and Tesch, 1978; Bartlett *et al.*, 1984). The **Weisberg method** is more complex than the others. It involves a modelling approach that enables age group and annual environmental effects to be distinguished. Thus there is a separation and identification of changes in growth from one time period to another, such as years of particularly good or poor growth, that may be superimposed upon age effects (Weisberg and Frie, 1987; Weisberg, 1993).

1.2.3. Analysis of length-at-age data

The two constants of the VBGF, L_∞ and k, can be estimated from measurements of fish length at known fish ages (Gulland, 1969, Bagenal and Tesch, 1978; Prein *et al.*, 1993). Before personal computer became widely available it was difficult to fit the VBGF to length-at-age data, and several methods were developed for the estimation of L_∞ and k.

One method involves making a plot of the annual increment of length (L_{t+1} - L_t) against length (L_t), where L_{t+1} - L_t is length-at-age $t+1$ and L_t is length-at-age t. This gives a straight line with a slope of $-(1 - e^{-k})$ and an intercept on the abscissa (i.e. where $L_{t+1} - L_t = 0$) equal to L_∞. This equation is also known as the Brody equation, as mentioned by Schnute and Richards (2002). This expression not only establishes the constants in the VBGF but also provides an indication of the decline in the rate of growth with age.

The constants of the VBGF can also be estimated from a plot of L_{t+1} on L_t, the Ford-Walford plot (Ford, 1933; Walford, 1946). The fish growth rate slows with age so that the plotted line gradually approaches a 45° line passing through the origin. The two lines will intersect at L_∞, the point of intersection indicating when the fish lengths at the start (L_t) and the end (L_{t+1}) of the growth period are identical, i.e. the fish has ceased to increase in length, and the annual growth increment is zero. The growth constant, k, can also be estimated from the plot of L_{t+1} on L_t because the slope of the line is equal to e^{-k}.

Much work has been done on developing methods for fitting and testing VBGF data, and with the advent of the personal computer, data handling has become much easier (Gallucci and Quinn, 1979; Misra, 1986; Ratkowsky, 1986; Cerrato, 1990, 1991; Xiao, 1994). Bayley (1977) pointed out that a weakness in several of the methods is a lack of independence between the variables plotted. In an attempt to overcome the problem, Bayley (1977) devised a method for the estimation of the VBGF constants (L_∞ and k) using measurements of instantaneous growth rates ($\delta(\ln W)/\delta t$) and a description of the length-weight relationship ($W = cL^m$). From these data Bayley (1977) derived an equation that led to a linear transformation of the non-linear VBGF:

$$\delta(\ln W)/\delta t = (m/L)\left[k(L_\infty - L)\right] = mk\left[(L_\infty/L) - 1\right] \qquad (10)$$

or

$$(\ln W_2 - \ln W_1)/(t_2 - t_1) = -mk + mkL_\infty(1/L) \qquad (11)$$

The latter equation has the form of a linear regression with a slope of mkL_∞, the intercept is $-mk$, and a plotted line will intersect with the abscissa at $1/L_\infty$, where, by definition, the instantaneous growth rate is zero. Thus, the constants of VBGF can be estimated from successive measurements of length and weight, and calculation of m in the length-weight relationship; instantaneous growth rate is plotted against the reciprocal of fish length, the slope and intercept of the regression calculated, and the VBGF constants are then estimated from the values obtained. Bayley (1977) suggested that this method of analysis could be appropriate for the estimation of the VBGF constants for tropical fish species in which age determination may be extremely difficult. For these species growth is often estimated from data collected following the recapture of released marked fish, where it is not usually possible to control the time over which individual fish are at liberty. Analysis of growth data using this methods does, however, require that there has been a marked change in fish weight and length over the growth period.

1.2.4. Analysis of length-frequency data

The use of size frequency to investigate the growth of animals dates back to the papers of the Danish biologist J. Petersen (1891, 1892) in which he presented length measurements of fish and found that with temperate species breeding once a year it is relatively easy to define a cohort by a year-class (a mode in the histogram showing the frequency distribution). This cohort can be followed during the first part of its life by tracing the corresponding modes in the histograms from the samples; but when they approach their maximum size this is no longer possible because, by then, fish of different ages have reached approximately the same size (Sparre and Venema, 1998).

Assessment analysis of exploited fish stocks requires some measure of biological time. Traditionally, the measure of biological time has been age. However, another measure of time is size and the simplest one to obtain, in many circumstances, is length. Age is a linear measure of time while length is, except for very particular circumstances or for a limited time or age span, a non-linear measure of time. Age information is, however, often difficult and expensive to obtain. Data on the age of individuals may contain substantial measurement error(s) and this added source of uncertainty in the assessment process may have considerable influence.

In spite of the complication of working with a non-linear measure of time, length-based methods of stock assessment are attractive for several reasons. Unlike ageing information, length data are simple and cheap to obtain and quite large samples are feasible. Length has the appeal of an intrinsically more biologically meaningful attribute than age. Both fishing and natural mortality are likely to be size-dependent rather than age-dependent. However, it is still necessary at the end of the day to return to a linear time-scale. Not only length is a non-linear measure of time but, more importantly, the relationship is unknown and must be estimated. This, as with age data, introduces an additional source of uncertainty to the assessment process. There is, in general, no best choice between an assessment method structured by age or size. In either case the estimation problems are substantial (Rosenberg and Beddington, 1988).

A vital component of any length-based model is a mean of estimating the growth parameters of the animals in the population, in other words, a method of determining the non-linear relationship between size and time. Size-based methods can be used to obtain estimates of growth, and mortality, when fish are difficult, or too expensive, to age using hard parts. The aim of these methods is to estimate growth, and mortality, from the relative frequency in size classes. Fish are generally born in discrete, often annual, cohorts, following an annual or seasonal breeding season, and individuals grow in size throughout life towards an asymptotic size. Size-frequency analysis looks for peaks of numbers in size classes to estimate the mean sizes of successive cohorts at integer intervals of age, and at the relative numbers in these cohorts to estimate total mortality rates. When properly used, size-based methods should lead to the same estimates of growth and mortality, as other techniques, although the sources and impacts of uncertainty are different. In some cases, size-based methods have advantages over, or can complement, conventional estimates based on direct ageing. Analytical methods for length-frequency data have a long pedigree in fisheries science, but none of them works as well as one would wish, and as a consequence many fisheries research have dabbled in the sport of inventing new methods at some stage or another of their careers (Pitcher, 2002).

The sizes of fish of similar age in a cohort vary about a mean. Fish populations usually comprise several such cohorts, which are mixed together in a sample. If we know the shape of the size distributions of the cohorts, we can try to dissect a mixed sample into its constituent cohorts. Length-frequency plots from a sample of a fish population are therefore mixtures of a series of overlapping length distributions (Everitt and Hand, 1981). Length-frequency analysis aims to dissect the mixture into its components. The average size and the relative abundance of the component cohorts provide measures of growth and mortality. First, if we follow the mean sizes in a series of samples, we can then estimate growth. Secondly, if we follow the changes in numbers of a cohort with time, provided that the changes accurately mirror changes in the underlying population, we can estimate the mortality rates. Variation among individuals in mortality and growth can be thought of as “smearing” the original cohort structure.

1.2.4.1. Distributions

It is generally assumed that the variation in length of any cohort follows a normal distribution. The expected frequency, *f*, at length *L* for a normal distribution of mean and standard deviation, is:

$$f(L \mid \mu, \sigma) = \frac{N \cdot dl}{\sigma\sqrt{2\pi}} \cdot e^{\left\{-0.5\left[\frac{(L-\mu)}{\sigma}\right]^2\right\}} \tag{12}$$

where N = sample size, μ is the mean length, σ is the standard deviation of the lengths, *dl* is the class width and *L* is the mid-point of the class. Other distributions are sometimes employed. The log normal, in which the lengths, means and standard deviations are transformed to logs, may be appropriate for weight-frequency analysis and sometimes for length-frequencies. The gamma distribution is also sometimes used (Pitcher, 2002).

For a mixture of normal distribution we set N to total sample size and obtain the expected frequency at length L as:

$$f_L = \sum \frac{N \cdot dl \cdot p_i}{\sigma_i \sqrt{2\pi}} \cdot e^{\left\{-0.5\left[\frac{(L-\mu_i)}{\sigma_i}\right]^2\right\}} \tag{13}$$

where N is now total sample size, p_i is the proportion of this total in the ith age group, μ_i is the mean of the ith age group, and σ_i is the standard deviation of the ith age group. For h component, the problem for length-frequency analysis is therefore to estimate the sets of proportions, means and standard deviations. The p_is must sum to one, so we have (3h-1) parameters to estimate:

p_1; σ_1; μ_1;
p_2; σ_2; μ_2;
p_3; σ_3; μ_3;
… … …
p_h; σ_h; μ_h;

Statisticians have shown that mixtures of normal distributions are identifiable (Yakowitz, 1969): that is, we can, in principle, determine all the parameters in the mixture provided that the assumption of normality is valid and we know exactly the combined probability. In practice, of course, we only have the data histogram to estimate the latter. There is a more detailed discussion of this point in MacDonald and Pitcher (1979).

1.2.4.2. The appearance of modes

Cohorts of fish which recruit at different times are consequently separated in mean size. The appearance of separate modes in a size-frequency plot of a sample taken from the whole population has long been interpreted by ecologists as revealing age groups (e.g. Petersen, 1891). Within any one cohort there will be a spread of size resulting from different birth dates and individual growth rates. This spread may obscure the modal size of the separate cohorts.

The conditions under which modes appear have been formally investigated. For two components in a mixture, Behboodian (1970) showed that separate modes will be seen (bimodality) if:

$$|\mu_1 - \mu_2| > 2\min\{\sigma_1, \mu_2\} \tag{14}$$

but even then, they will not necessarily be clear to the eye for small sample sizes.

Three main factors in the fish population conspire to reduce the separability of modes in length-frequency data.

First, if fish grow according to the von Bertalanffy curve, as they approach L_∞, the cohort means get closer together and are therefore less likely to reveal modes. This is known as the "pile-up" effect (Fig. 1.5).

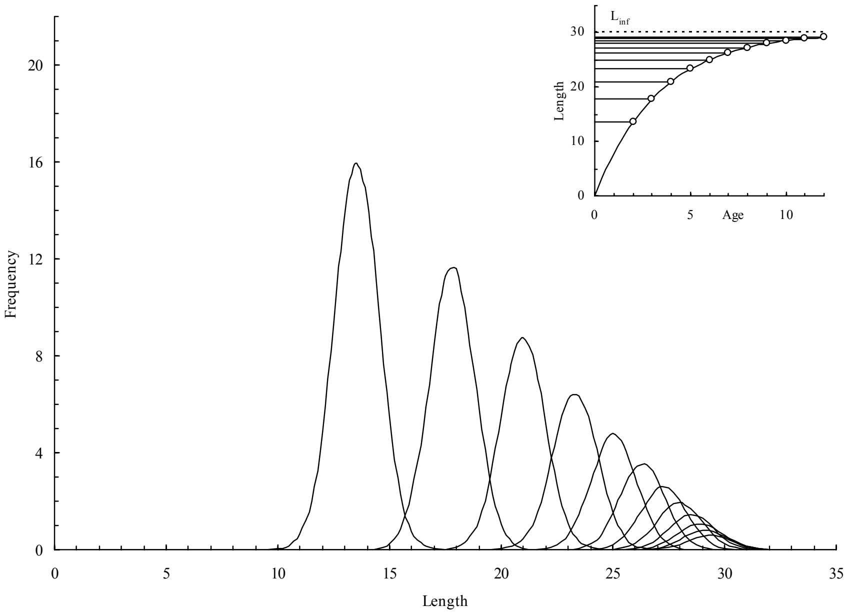

Fig. 1.5 Diagram illustrating the "pile-up" effect. The larger diagram shows normal distributions of length around the mean lengths of 10 successive annual cohorts. Inset: length-at-age projected (horizontally) from each mean length at integer age (circles) on a von Bertalanffy growth curve (Diagram taken from an animated spreadsheet available from *http://www.fisheries.ubc.ca/projects/length.php*).

Secondly, variance in length-at-age increases with length as fish get larger and approach L_∞, and so age groups are more likely to overlap. For randomlyvarying L_∞, Rosenberg and Beddington (1987) show that modes will appear in a two-cohort mixture if:

$$\left[L_\infty \cdot e^{-k(t-t_0)}\right] \cdot \left(e^{-k} - 1\right) > 2s^2 L\left[1 - e^{-k(t-t_0)}\right]^2 \qquad (15)$$

where s^2L is the variance at length L. This function will vary with length, so that separate modes are less likely at greater lengths if s^2L increases. Unfortunately, the way in which s^2L changes with size can be quite complex and there has been no rigorous investigation using actual fish growth. Rosenberg and Beddington (1987) show that if differences in L_∞ are the main source of variation between individual fish, s^2L increases with fish size. On the other hand, if most variation between fish is in the growth parameters k, s^2L peaks at about half of L_∞ and then drops as fish approach the asymptotic size. Empirical data usually show variance in length increasing with size, so that for sizes up to 0.7 L_∞ the assumption of a constant coefficient of variation of length (COV-l) seems reasonable.

The first two problems above affect older age groups more seriously. But the third mechanism, which may obscure modes, can affect young and old age groups alike. If recruitment of cohorts is continuous, or extended over a large portion of the year, the variance in length by age group will be large and modes may be obscured from young ages on. Unfortunately, recruitment may occur over an extended season in some tropical fisheries for which length-based methods are otherwise ideal.

If modes are present, they probably reveal cohorts, but if modes are absent, there can still several cohorts present. Moreover, if modes appear, the simple graphical or approximate computer methods will give good results. If there are no modes, one of the statistical methods will be needed. In their review of length-based methods, Rosenberg and Beddington (1988) recommend the greater use of formal statistical methods, which are not so dependent upon the appearance of modes.

Pitcher (2002) presents an index of overlap which will, in conjunction with a consideration of sample size, indicate whether modes are likely to appear. This in turn will allow the researcher to decide whether simple graphical or *ad hoc* methods are likely to be adequate. The first step in the calculation of an index is to decide roughly what the likely means and standard deviations of the proposed age groups are. The overlap index can then be calculated as follows:

$$V = \sum_{i=1}^{i=h-1} \left\{ \left[(\mu_i + q\sigma_i) - (\mu_{i+1} - q\sigma_{i+1}) \right] \Big/ \left[(\mu_i + q\sigma_i) - (\mu_i - q\sigma_i) \right] \right\} \Big/ h \qquad (16)$$

where q = 1.96 to give 95% limits, and h = number of age groups. This is then repeated in order to compare several alternative hypotheses. The index V reflects the average proportion by which the 95% zone (i.e. 19 out of 20 fish of this age) for the age group is overlapped by the 95% zone for the next age group. When V is negative, there is a very wide separation of the age groups. When V is greater than about 0.25, modes disappear. The V for individual age groups can also be usefully examined where the separation of adjacent ages differs across the length-frequency plot.

1.2.4.3. Assumptions of length-frequency analysis

For length-based method to work, fish must recruit in discrete cohorts. Discrete cohorts usually derive from separate spawning seasons, but there may be more than one of these per year. The cohorts must remain discrete as the fish grow older. This requirement may be relaxed to a certain extent for different methods of analysis, but, generally, the methods work better the more discrete the cohorts and the more separate they remain as they get older. This implies that the growth of individuals in a cohort should be similar, i.e. the variability in growth rates among individuals of the same ages is not large.

So there are two sources of variation in size within a cohort of fish:

- different birth dates within the spawning season;
- different growth rates among individuals.

The first of these can be accommodated by most length-based methods, provided that the variance is not too large. But the second is a major problem for all the methods, as it tends to destroy cohort structure (Pitcher, 2002).

A further assumption is that length-frequency data in your sample fully represent the length classes in the fish stock. If they do not, then the sample data will need to be adjusted to compensate for the selectivity of the sample gear. A net series of tests for this employs the relationship among length at maturity, L_m, age of maximum yield-per-recruit, L_{opt}, and temperature in order to evaluate the validity of the length-frequency sample (Froese and Binholan, 2000).

The starting point in all analyses is the length-frequency distribution, adjusted if necessary, with known class width and class boundaries. It is worthwhile taking a lot of care over the class boundaries: lower bound, mid-point and upper bound of the classes are all used in different methods.

1.2.4.4. Limits of length-frequency analysis

The use of modes in size frequency distributions of aquatic organisms have been advocated as an attempt to identify groups of fish with similar age. This would be the case if the sample of size is unbiased and the species under analysis reproduces during a relatively short span of time at regular periods (King, 1995). The life history characteristics determine the relative contribution of each age group to the population and the sample, the distance between the mean lengths-at-age and the amount of overlapping (Castro and Erzini, 1998; Erzini, 1990, Isaac, 1990). Particularly in the case of older age groups, where overlapping is most significant and large individuals may not be adequately represented, the ability to separate mixture of distributions is affected by sample size and interval width (Hoenig *et al.*, 1987; Erzini, 1990, Isaac, 1990). Schnute and Fournier (1980) remark that length-frequency analysis tends to lump the final age-classes together if they are in close proximity or contain small percentages of fish. In such cases it may be impossible to distinguish the final ages, and the best approach may be to assume that all fish beyond a certain age comprise a single group.

Length-frequency distributions are commonly analyzed by means of histograms and frequency polygons. In spite of their wide usage, these density estimators may be too crude for many purposes (Tarter and Kronmal, 1976). According to Fox (1990), four problems are encountered when using histograms:

1. *Dependency on the origin*. The investigator must choose the position of the origin of the bins (very often by using convenient "round" numbers). This

subjectivity can result to misleading estimations because a change in the origin can change the number of modes in the density estimation (Silverman, 1986; Fox, 1990; Scott, 1992).

2. *Dependency on the width and number of intervals (bins)*. Smoothness of the frequency distributions depends on both these parameters. The use of many bins results in a noisy estimator, and on the other hand, few bins reduce distribution details. Frequently, the number and width of the bins are determined arbitrarily despite their importance. When data are grouped, it is assumed that the midpoint of each class can represent the original measurements that fell within the class boundaries without significantly affecting subsequent analysis and identification of modes. By not making a distinction between measurements falling in the same intervals, information is lost and the larger the interval or class size, the larger the lost. On the other hand, by increasing the intervals number and decreasing interval size, more effort is required in sampling, homogeneity is decreased and errors in sampling may take on added importance (Guiasu, 1986; Erzini, 1990). In fisheries, a compromise has often to be made between measuring a small fish number slowly and accurately and grouping measurements in small class intervals, as well as to be able to distinguish modes or peaks in the size frequency and measuring a large number of individuals in the same period of time with a coarser unit of measurement and class interval. Obviously, the coarser the unit of measurement, the greater the difficulty of distinguishing successive modes in the size frequency distribution as they approach on another more closely with size (Caddy, 1986).

3. *Discontinuity*. This histogram characteristic is function of the arbitrary bin locations and the discreetness of data rather than of the population that is sampled. The local density is only computed at the midpoint of each bin and then the bars are drawn assuming a constant density throughout each bin (Chambers *et al.*, 1983).

4. *Fixed bandwidth*. Usually, data density has a non Gaussian behaviour, and it is difficult to choose an optimal bandwidth following simple rules. If a fixed bin is narrow enough to show details where density is high, it cannot avoid noise

where density is low. This problem is often addressed by varying the binwidth, but the height of the bar is no longer proportional to its area, which may lead to misinterpretation.

1.2.4.5. Classification of length-based analysis methods

Methods developed over the years for the analysis of length-frequency data have tended to fall into two groups: parametric and non-parametric (Fig. 1.6). Another classification is into simple *ad hoc* methods, that are often essentially graphical or non-parametric, and rigorous statistical estimation methods, usually parametric (Pitcher, 2002).

Analysis of length frequency data	**Parametric methods**	**Graphical methods**	**Taylor method**	Taylor, 1965
			Bhattacharya method	Bhattacharya, 1967 Pauly and Caddy, 1985 Goonetilleke and Sivasubramaniam, 1987
			Cassie method	Harding, 1949 Cassie, 1954 Harris, 1968
			Tanaka method	Hald, 1952 Tanaka, 1953, 1962
		Computational methods	**NORMSEP** (Normal Separator Program)	Hasselblad, 1966 Hasselblad and Tomlinson, 1971 Pauly and Caddy, 1985
			ENORMSEP (Extended Normal Separator Program)	Yong and Skillman, 1975
			MIX technique	Petersen, 1891 MacDonald and Pitcher, 1979 MacDonald and Green, 1986
			MULTIFAN	Fournier *et al.*, 1990
	Non parametric methods	**ELEFAN I** (Electronic length-frequency analysis)		Pauly and David, 1980, 1981 Pauly, 1982, 1987
		SLCA (Shepherd's length-composition analysis)		Shepherd, 1987a Isaac, 1990 Terceiro and Idoine, 1990 Pauly and Arreguin-Sanchez, 1995
		Proj (Projection matrix method)		Rosenberg *et al.*, 1986 Shepherd, 1987b
		Powell-Wetherall method		Powell, 1979 Wetherall, 1986 Wetherall *et al.*, 1987

Fig. 1.6 Classification of length-based analysis methods.

Parametric methods, also called modal analysis methods, depend upon the estimation of means, standard deviations and proportions or numbers in each of the cohorts in the mixed sample. These are the parameters of the size-frequency distributions, hence the term parametric. The size distributions are generally taken as normal, but log normal and gamma distributions may also be employed (MacDonald and Pitcher, 1979). The methods include both *graphical* (e.g.

probability plots) and *computational* (e.g. mixture analysis) methods, but all make strong assumptions about distributions. In parametric methods the number of cohorts generally has to be determined by the user, and several scenarios may have to be compared.

Non-parametric methods do not depend directly upon estimating the parameters of the cohort distribution and directly estimate growth parameters from the length-frequencies. So they make only weak assumptions about the distribution of sizes within the cohorts, i.e. that they are roughly distributed about some modal or central value, and hence are analogous to non-parametric statistics. Modal lengths of each cohort are fixed to lie upon a curve described by a growth model. Generally the von Bertalanffy model is used, but other models such as a seasonal growth model, can be employed. Hence, the non-parametric methods make strong assumptions about growth. In non-parametric methods, cohorts number is implicit in the estimates of growth model parameters, and may be revealed when cohorts are sliced in age groups (Pitcher, 2002).

1.2.4.5.1. Parametric methods

1.2.4.5.1.1. Graphical methods

Graphical methods have the advantage of being quickly performed with a simple spreadsheet, or even pencil and paper, and bypass statistical difficulties. In most methods of this type, successive components are extracted sequentially from data (Pitcher, 2002).

Modal Progression Analysis, the simplest and oldest method, entails the graphical joining of cohorts that appear as clear modes. Problems arise when deciding which cohorts to join up with which others. For species that actually shrink, such as octopus, lamprey (*Lampetra* spp.), this may be one of the few methods applicable. Modal progression analysis can also be used on the results from a series of formal single-sample estimations: a clear example is discussed by Sparre and Venema (1998).

Gulland and Rosemberg (1990) outlined simple interpretations that may be made from visual inspection of length-frequency plots. Type A, a single mode that stays in the same place through time, can be produced by gear with high selectivity, such as gill-nets, or by fish, for example yellowfin tuna (*Thunnus albacores*), that migrate with age. The authors say that not much can be done with type A. Type B, a single mode moving steadily upwards, is typical of single-cohort fisheries such as prawns or squid, that are good candidates for any simple analysis. Type C, with many clear modes, may also be a good subject for the classical techniques described below. Type D, with smeared modes, may be hard to analyse.

The use of probability plots was reinvented several times by fisheries workers (Harding, 1949; Cassie, 1954; Harris, 1968). Originally they were done on special probability paper, but today it is easy to set them up on a spreadsheet using the built-in normal distribution function. A series of progressively more sophisticated graphical methods were based on the slop change of a parabolic function of frequency and length (Buchanan-Wollaston and Hodgeson, 1929; Hald, 1952; Tanaka, 1953, 1962; Bhattacharya, 1967; Akamine, 1985; Pauly and Caddy, 1985; Goonetilleke and Sivasubramaniam, 1987). Taylor (1965) invented an intricate method. After smoothing the data histogram, components are sequentially extracted from the shape of the left flank of the distribution.

Among the graphical methods, that proposed by Bhattacharya (1967) is one of the most used for the separation of normally distributed groups from a mixture of normal distributions. This method is based on:

- assumed normal distribution of the components in a composite length-frequency distribution;
- transformation of the normal distributions into straight lines;
- calculation of N (sample size), μ (mean length) and σ (standard deviation of the lengths) by regression analysis.

A normal distribution can be transformed into a straight line by the following steps (Kolding and Ubal Giordano, 2002):

1. Taking the logarithms of the function value

$$\ln\left(f(x)\right)=\ln\left[\frac{N\cdot dl}{\sigma\cdot\sqrt{2\pi}}\cdot\exp\left(-\frac{(x-\mu)^2}{2\cdot\sigma^2}\right)\right] \tag{17}$$

By plotting these new function values against the independent value *x*, a parabola is obtained.

2. The parabola can be transformed into a straight line by calculating the difference of two adjacent function values $y = \ln f(x+dl) - \ln f(x)$ and plotting a new independent value $z = x + dl/2$.

3. The linear regression through these points has the properties that the intercept

- $a = \dfrac{dl \cdot \mu}{\sigma^2}$ and the slope
- $b = \dfrac{-dl}{\sigma^2}$ thus, the mean value can be calculated
- $\mu = \dfrac{-a}{b}$ and the variance $\sigma^2 = \dfrac{-dl}{b}$.

This regression is the main element of the Bhattacharya method. When the frequencies in the length intervals (*dl*) are assumed to be normally distributed, they are regarded as the function values. Then, by using the logarithms of the frequencies, computing the difference of two adjacent pairs by subtraction (i.e. $(\ln(dl+l) - \ln(dl))$), and by plotting the difference against the upper limit of *dl*, a scatter diagram that can be linearised by regression is obtained. The intercept and slope of the regression line will then be an estimate of the regression values of the true normal distribution, approximating the frequency distribution.

In a composite length-frequency distribution with several more o less overlapping normally distributed components, the procedure is to identify and calculate the relative contribution of each component step by step (Fig. 1.7). In other words, one component at a time must be isolated:

1. find the mean and variance of the first component by the above method,

2. use these figures to calculate the theoretical number of elements in each interval of the first component (this is only necessary in the overlapping length intervals of the first and second component),
3. subtract these values from the elements in the sample, so the sample now is composed of all parts minus the first component,
4. repeat the whole procedure with the second component (that in fact has become the first),
5. repeat as long as proper identification of components is possible.

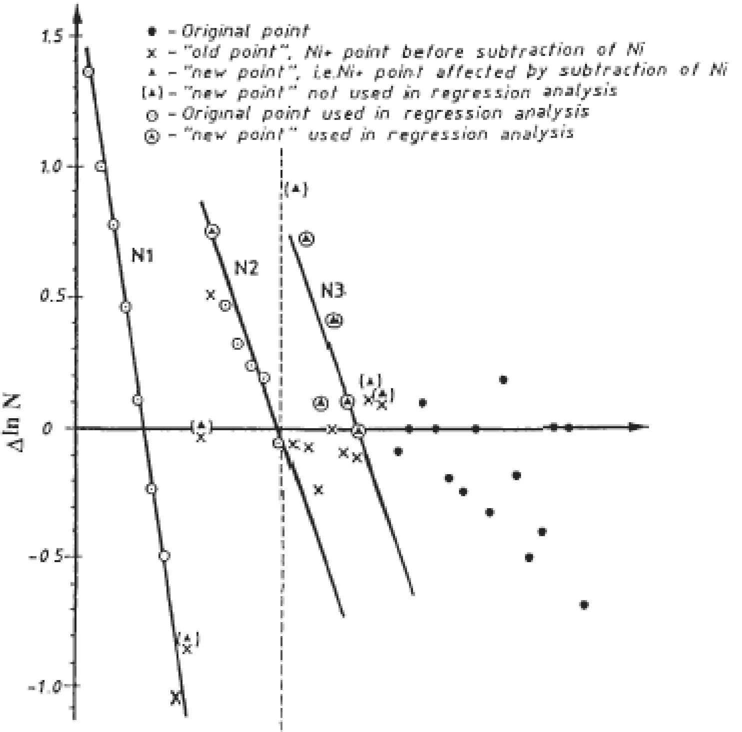

Fig. 1.7 Example of the Bhattacharya method applied to a composite length-frequency distribution. The regression lines are represented for the first three cohorts (Diagram taken from Sparre and Venema, 1998).

1.2.4.5.1.2. Computational methods

These methods work by calculating a Goodness-Of-Fit (GOF) between the sample data and a distribution mixture specified by its component parameters. The history of this method is reviewed by MacDonald and Pitcher (1979). GOF is calculated as the difference between the sample data and the fitted mixture of distributions. The methods usually work by searching automatically for a maximum GOF, but the user can also intervene and guide the fitting process. The number of component cohorts is usually the user choice, guided by the GOF values of alternatives. Alternative fits with different numbers of component age groups can be compared:

$$\chi^2 = \sum \left\{ \left[(obs_L) - f_L \right]^2 / f_L \right\} \qquad (18)$$

This is the basis of statistical mixture analysis, originally embodied in the MIX technique (MacDonald and Pitcher, 1979), although its statistical roots go back to Petersen (1891).

The main problem in using the MIX approach is to obtain the number of components in the mixture. The approach recommended by MacDonald and Pitcher (1979) and MacDonald and Green (1988) is to get the best fit for $h - 1$, h and $h + 1$ components where h is the guessed number of components, the final choice of number of age classes being mainly on the basis of the minimum chi-squared. Rosenberg and Beddington (1987) show that MIX growth parameter estimates are quite robust against small mistakes in obtaining the number of components.

A more complex but essentially similar statistical method, MULTIFAN (Fournier *et al.*, 1990), gets around the problem by using a von Bertalanffy curve to provide the number of cohorts in a similar fashion to the non-parametric methods. In fact, results from MIX and the more complex multi-sample MULTIFAN are generally very similar (Wise *et al.*, 1994; Kerstan, 1995).

Experience suggests that MIX is robust for single-sample analysis, although it tends to underestimate k (Rosenberg and Beddington, 1987). It has advantages where there is a series of samples, if there is any reason to suspect that growth does not follow a von Bertalanffy curve. This can happen in some fish that switch to piscivory during their lifespan (LeCren, 1992). The additional work in the multi-sample MIX technique is to join cohorts in successive samples using an MPA-like method, which can be both an advantage and a disadvantage. Modifications to the MIX approach can easily incorporate information about growth (e.g. Liu *et al.*, 1989) either as starting values for mean cohort sizes and/or as additional constraints on the fitting process. Schnute and Fournier (1980) published an alternative version of this process.

In the tropics, there is often more than one cohort recruiting each year, that is a consequence of monsoon-like seasonality in productivity. For example, Koranteng and Pitcher (1987) used MIX to analyse length-frequency data for a West African sparid fishery, where a cohort recruited after each of the two major upwellings each year. The plot of estimated means from the MIX was best joined up using a strong assumption that there were two cohorts per year. In fact, similar results can be obtained using ELEFAN (see below) if similar assumption is made (Pauly, *personal communication* in Pitcher, 2002).

1.2.4.5.2. Non-parametric methods

Most non-parametric methods work by scanning a range of L_∞ and k value and working out a Goodness-Of-Fit (GOF) for each combination. The best GOF is searched for by user or by automatic search, or a combination of both. The best fit gives the growth estimate. Usually, these methods attempt to do this by fitting a growth curve through a whole set of samples taken through time. The von Bertalanffy curve, or its seasonal modification, is ordinarily employed, although it is possible to use other growth models or even empirical growth values, but these options have rarely been used. A GOF function based on how well the growth curve passes through the *pecks* and the *troughs*, is maximized for a range of values of L_∞ and k. So growth, and sometimes mortality, is estimated along with the dissection of the length-frequency curves (Pitcher, 2002).

1.2.4.5.2.1. ELEFAN (Electronic LEngth-Frequency Analysis)

Daniel Pauly was the first to realize the potential of this type of method, and working versions of his original ELEFAN first appeared in the late 1970s (Pauly and David, 1980, 1981; Pauly, 1982) for the estimation of growth parameters and mortality in fish populations, and later improved by Brey and Pauly (1986) and Brey *et al.* (1988). Nowadays, the modern version of this length-frequency method is the ELEFAN I module of the widely-used FiSAT (Fish Stock Assessment Tools) package distributed by *FAO* (Food and Agriculture Organization) (Gayanilo *et al.*, 1988, 2002; Gayanilo and Pauly, 1989). Pauly (1987) has written a very clear review of the basis of the method.

ELEFAN I works by attempting to find a maximum for a GOF function based on peaks and troughs: *the explained sum of peaks*. This is based on how often a von Bertalanffy growth curve hits modes in the data. During fitting, growth curves with different parameters are run and mapped. The maximum of the scoring function is chosen as the best fit. A seasonally modified curve can easily be substituted for the standard von Bertalanffy and, in fact, the same GOF technique could be used for any growth curve or pattern. It should be noted that when only one sample is available, the seasonally oscillating modified curve of the VBGF cannot be applied.

The identification of modes (or peaks) is obtained through a so-called “restructuring” procedure, performed for each sample via the following steps:

1. computation of a 5-point moving average;
2. calculation of the adjusted frequencies, by dividing the observed frequencies of each class by the corresponding moving average;
3. computation of the relative adjusted frequencies by dividing the adjusted frequencies by the average of all adjusted frequencies within sample, then subtracting 1;
4. a procedure to avoid the attribution of extreme values to isolated frequencies (adjacent to zero frequencies), generally at either end of the distributions;
5. a procedure to obtain equal sums of positive and negative values within a sample.

After restructuring a sample, either a positive value (peak), a negative value (trough) or a zero value corresponds to each length class. Figure 1.8 shows an example of the effect of restructuring the data in a hypothetical sample. In this context, groups ("runs") of adjacent length intervals with positive values are assumed to potentially represent cohorts.

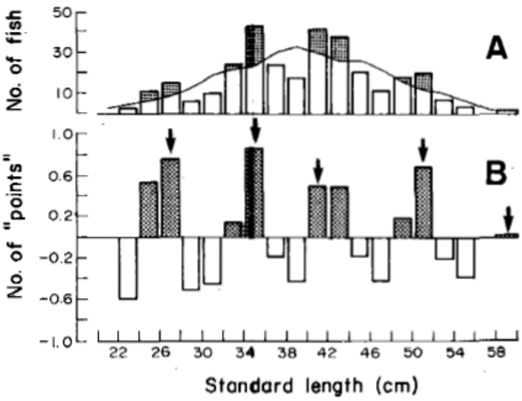

Fig. 1.8 A) Original length-frequency data and running average frequencies over 5 length classes. Peaks are represented by the shaded areas above the running average. B) Data after the restructuring process. Arrows show the points used in the computation of ASP (Diagram taken from Pauly, 1987, based on Goeden, 1978).

The number of peaks gives the maximum *available sum of peaks* (ASP). A von Bertalanffy curve for the specified L_∞ and k is traced through data starting at the base of the first peak. A point is scored each time the curve hits one of the peaks, a point is deducted each time it hits a trough. This repeated for starting times equal to the base of each peak, the maximum value is the *explained sum of peaks* (ESP). The GOF function is the ratio ESP/ASP. This process is repeated for all required combinations of L_∞ and k, the GOF mapped and the maximum value chosen as giving the best growth parameters. For each combination of L_∞ and k, it is possible to search for the value of t_0, the starting point within a year for the growth curve, relative to the data, which maximizes the ESP/ASP ratio. Note that absolute ages are needed to find the true t_0 (Pitcher, 2002).

Simulations show that ELEFAN I can give clear and correct answers where peaks are well separated in the data, but it tends to underestimate k (Rosenberg and Beddington, 1987). There are two problems with the ELEFAN I technique. First, it seems sensitive to the appearance of discrete modes in the data. Second, because it is an *ad hoc* method, it lacks explicit statistical error structure and therefore provides neither standard errors of the estimates nor a guide to performance in any situation.

But the latter problem could today be investigated using Monte Carlo simulation methods (Halton, 1970; Hilborn and Mangel, 1997).

Like other non-parametric methods, ELEFAN I does not directly evaluate multiple recruitments during a year, as occurs in many tropical fisheries, although there is a recruitment pattern routine that helps to detect multiple recruitment pulses. Alternative growth models can be used instead of the von Bertalanffy, and one that has been frequently employed is a seasonal version of this growth curve (Pitcher, 2002).

1.2.4.5.2.2. SLCA (Shepherd's Length-Composition Analysis)

Shepherd (1987a) introduced an objective GOF function for detecting peaks and troughs, using a damped sine-wave function borrowed from time-series analysis of diffraction patterns. The damped sine-wave function emulates the decreasing spacing of means lengths-at-age of the von Bertalanffy curve. The SLCA method is conceptually very similar to ELEFAN I, the value of a scoring function being mapped against a range of values of L_∞ and k.

Values of L_∞ and k are chosen for a von Bertalanffy curve. For each length interval L, t_{max} and t_{min} are calculated as the ages corresponding to the start and mid-point of the interval using the growth equation, t is the average of t_{max} and t_{min}. The test function T_L is estimated as:

$$T_L = \left[\sin(\pi Q)/(\pi Q)\right] \cdot \left\{\cos\left[2\pi\left(t - t_s\right)\right]\right\} \tag{19}$$

where $Q = (t_{\max} - t_{\min})$ and t_s is the proportion of the year since recruitment until when the sample was taken. The GOF function is then calculated over all length groups as:

$$S = \sum \left\lfloor \left(T_L \sqrt{N_L}\right) / \Delta t_L \right\rfloor \tag{20}$$

where N_L is the number in each length class, and Δt_L is the time needed to grow through each length class:

$$\Delta t_L = -1/k \cdot \ln\left[(L_\infty - L_u)/(L_\infty - L_d)\right] \tag{21}$$

where L_u is the upper bound of the length class and L_d is the lower bound. This modification was introduced by Pauly and Arreguin-Sanchez (1995).

To estimate t_0, this is run with t_0 set to zero, to give *Sa*, then again with t_0 set to 0.25, giving *Sb*. The maximum score, S_m, for the current combination of growth parameters is then given by:

$$S_m = \sqrt{(Sa^2 + Sb^2)} \qquad (22)$$

For any one pair of values L_∞ and *k*, t_0 can be easily found as:

$$t_0 = \arctan(Sb/Sa)/2\pi \qquad (23)$$

The above procedure is repeated for all the L_∞ and *k* combinations under consideration, and the values of GOF, S_m, are entered into a table of results so that the maximum may be identified. Contours of S_m may be mapped to avoid picking local maxima. As with ELEFAN I, the upper limit of length classes needs truncating to avoid bias from the “pile-up” effect. The “pile-up” effect can be minimized by the use of the Pauly and Arreguin-Sanchez modification (Pitcher, 2002).

Provided that ages, as defined by the start point in the analysis, are known, Shepherd’s method can provide a direct estimation of t_0. Published simulations suggest that it is more robust than the ELEFAN I algorithm (Basson *et al.*, 1988). Provided that the modes for the younger fish are reasonably clear in the samples, it seems less sensitive to the appearance of modes overall. But Terceiro and Idoine (1990) showed that SLCA suffers from the same general problems as the other methods.

The algorithm of SLCA is firmly linked to the von Bertalanffy model, and it would be hard to modify it for seasonal growth or alternative growth models (Pitcher, 2002).

1.2.4.5.2.3. The PROJection MATrix (PROJMAT) method

The projection matrix method was initially devised for forecasting catch at length by projecting length compositions forward in time (Shepherd, 1987b). It was adapted for estimating growth parameters from a series of samples by Rosenberg *et al.* (1986).

A projection matrix can be constructed for any given growth equation. This matrix is analogous to a **Leslie population projection matrix** (Leslie, 1945), but instead of projecting vectors of proportions in age classes through time, vectors of proportions in length classes are projected through time.

The model of Leslie is one of the most heavily used models in population ecology. This is a discrete-time model of an age-structured population that describes development, mortality and reproduction of organisms. The model is formulated using linear algebra.

The model of Leslie describes 3 kinds of ecological processes:

1. development (progress through the life cycle),
2. age-specific mortality,
3. age-specific reproduction.

Variables and parameters of the model are:

- $N_{x,t}$ = number of organisms in age x at time t (age is measured in the same units as time, t). Usually, only females are considered and males are ignored because, as a rule, the number of males does not affect population growth.
- s_x = survival of organisms in age interval from x to x+1.
- m_x = average number of female offsprings produced by 1 female in age interval from x to x+1 (mortality of parent and/or offspring organisms is included).

There are two equations:

$$N_{x+1,t+1} = N_{x,t} \cdot s_x \tag{24}$$

$$N_{0,t+1} = \sum_{x=0}^{n} N_{x,t} \cdot m_x \tag{25}$$

Equation (24) represents development and mortality, whereas equation (25) represents reproduction. Equation (25) specifies the number of individuals in the first age class and equation (24) specifies the number of individuals in all other age classes. In the equation (24), the number of individuals in age x+1 in time t+1 equals to the number of individuals in the previous age and previous time multiplied by age-specific survival rate s_x. In the equation (25) the number of new-born organisms equals to the number of mothers ($N_{x,t}$) multiplied by the numbers of offspring produced (m_x). The number of offsprings is summed over all ages of mothers.

These two equations can be combined into one matrix equation:

$$N_{t+1} = A \cdot N_t \tag{26}$$

where N_t is the vector of age distribution in the population at time t, and A is the **transition matrix**.

A

M_0	m_1	m_2	m_3	M_4
S_0	0	0	0	0
0	s_1	0	0	0
0	0	s_2	0	0
0	0	0	s_3	0

N_t

$N_{0,t}$
$N_{1,t}$
$N_{2,t}$
$N_{3,t}$
$N_{4,t}$

N_{t+1}

$N_{0,t+1}=\Sigma N_{x,t}\cdot m_x$
$N_{1,t+1}=N_{0,t}\cdot s_0$
$N_{2,t+1}=N_{1,t}\cdot s_1$
$N_{3,t+1}=N_{2,t}\cdot s_2$
$N_{4,t+1}=N_{3,t}\cdot s_3$

Each column specifies the fate of organisms in a specific state. The number in the intersection of column *i* and row *j* indicates how many organisms in state *j* are produced by one organism in state *i*. In the Leslie model, organisms state is defined by age only. For example, the third column corresponds to age $a = 2$. An organism in age 2 produces *m* offsprings of age 0 (first cell in the column), and goes to age class 3 with probability *s* (the cell under main diagonal).

Matrix models are easy to iterate in time. In the next time step we again multiply the transition matrix by the vector of age distribution:

$$N_{t+2} = A \cdot (A \cdot N_t) = A^2 \cdot N_t \tag{27}$$

$$N_t = A^t \cdot N_0 \tag{28}$$

This equation can be used to simulate as many time steps as necessary.

The projection matrix method, developed by Shepherd (1987b), combines a time series length compositions and estimates of growth parameters to produce estimates of future length compositions in the absence of mortality, i.e. it attempts to make short-term forecasts (1-2 years) of catch rates and hence catches. The model requires a time series (not necessarily long) of length compositions, that may be taken as indicative of population abundance, together with estimates of the parameters of a suitable growth equation for the stock, e.g. von Bertalanffy growth equation. Note that, unlike the SLCA and ELEFAN I methods, that can be used with only a single length-frequency distribution, the PROJMAT method requires that at least two length-frequency distributions are available.

The numbers in any size group at time (*t*+1) can be predicted from the numbers in that group at time *t*, using growth, mortality and recruitment from length group smaller in size:

$$f\left[g, Z, (f_i)t\right] \rightarrow f\left[g, Z, (f_i)t+1\right] \tag{29}$$

Now , if constant mortality is assumed over the time interval, or the pattern with size is known, only the growth model parameters will affect the projected numbers.

First, using the first set of parameters for the growth curve, the expected length-frequency is projected forward from the first sample in the set. Secondly, the GOF of this expected data in each class *i*, proj_i, is compared with the actual length-frequencies, obs_i, using least squares:

$$GOF = \sum \left[(obs_i - proj_i)^2\right] \tag{30}$$

Thirdly, the projection of expected values is repeated using the next set of values for the growth curve parameters. This is repeated for the whole range of parameters and the GOF values tabulated and contoured so that, as with SLCA, the best fit can be chosen. Note that here a minimum value of GOF is necessary. As with SLCA and ELEFAN I, the upper-length classes need truncating to avoid bias from the “pile-up” effect (Pitcher, 2002).

The PROJMAT method can perform well under a wide range of conditions (Basson *et al.*, 1988). Unlike all the other non-parametric and graphical methods, the PROJMAT method does not rely on the appearance of peaks and troughs (modes) in the data, an advantage it shares with parametric distribution mixture methods. It is also robust against increase of variance in length with age. Another advantage is that any growth model could be used for the projection. In its basic form it suffers from the same multiple recruitment problem as ELEFAN I and SLCA, but, like ELEFAN I, it could be easily modified to deal with this (Pitcher, 2002).

1.2.4.5.2.4. The Powell-Wetherall method

Wetherall (1986) and Wetherall *et al.* (1987), based on Powell (1979) developed a technique from the principle that the shape of a representative size distribution of a population is determined by the value of asymptotic length (L_∞) and the ratio between total mortality rate and growth constant (i.e. by Z/k). These parameters are then estimated by means of a relatively simple regression calculation.

Requirements for application of the method are:

- the sample is representative of a steady-state population, i.e. recruitment and mortality are constant;
- recruitment is continuous;
- growth follows the von Bertalanffy model (without seasonal oscillation);
- growth is deterministic, i.e. there is no individual variability in the growth parameters.

Because a steady-state population is difficult to find in nature, the length samples available from a population with discontinuous recruitment are pooled into one sample, which will usually lead to a reasonable approximation of a steady-state distribution. Moreover, fishes that are not fully selected are not considered.

The Powell-Wetherall (P-W) method is based on the method of Beverton and Holt (1956) from estimating Z from mean length (L):

$$Z = k\left(\frac{L_\infty - L}{L - L'}\right) \qquad (31)$$

where

L_∞ = asymptotic length,

k = growth constant,

L = mean length of fishes above L_c,

L' = a length upward of which the fishes are fully selected.

Rearranging this equation and considering L and L' as variables:

$$L = L_{\infty}\left(\frac{1}{1+Z/k}\right)+\left(\frac{Z/k}{1+Z/k}\right) \tag{32}$$

which implies that mean length (L) is a linear function of cut-off length (L').

The idea of the method is to partition the length-frequency sample using a specified sequence of L' values. Thus, for a series of arbitrary cut-off lengths (L'_i), it is possible to calculate the corresponding L_i, i.e. the mean length of all fishes longer than the actual L'. In practice, L'_i values are taken as the lowest limits of each length class (i).

A regression analysis of such a data series provides an estimate of the intercept (α) and of the slope (β) of the linear function. With

$$\alpha = \frac{L_{\infty}}{1+Z/k} \tag{33}$$

and

$$\beta = \frac{Z/k}{1+Z/k} \tag{34}$$

which can be solved for the parameters L_{∞} and Z/k as:

$$L_{\infty} = \frac{\alpha}{1-\beta} \tag{35}$$

and

$$Z/k = \frac{\beta}{1-\beta} \tag{36}$$

The method was slightly modified by Pauly (1986): instead of plotting successive mean lengths (L_i) against their corresponding L'_i, the difference (L_i- L'_i) can be plotted against L'_i. Thus:

$$L_i - L_i' = \alpha + \beta L_i' \qquad (37)$$

the parameters being

$$L_\infty = \alpha / -\beta \qquad (38)$$

and

$$Z/k = \frac{1+\beta}{-\beta} \qquad (39)$$

This modification permits graphic visualization of L_∞ as the point where the line intercepts the abscissa.

Since the results obtained with the P-W method depend on the length classes included in the regression, only the points belonging to the right side of the mode of the underlying distribution were used, beginning with the point corresponding to the mode itself.

1.2.4.5.2.5. Summary: non-parametric method

All four non-parametric methods can easily give silly answers, and should only be applied with care and with insight of the ecology of the fish under study.

Using Monte Carlo simulations, Isaac (1990) compared how ELEFAN I, SLCA and P-W method perform under a variety of conditions and provided some helpful guidelines:

1. the ELEFAN I method seems to be more adequate for populations of small fishes with faster growth and shorter life span; however, the parameter *k* is always underestimated and L_∞ always overestimated.
2. the SLCA method shows a relatively high variability in the estimates. As opposed to ELEFAN I, the bias of this method is smaller for fishes with slow growth rates and greater for fishes with fast growth rates.
3. the P-W method shows a clear tendency to overestimate both L_∞ and *Z/k*; this is more pronounced for fishes with slow growth and long life span.

The tendency of ELEFAN I method to underestimate *k* may also be partially due to the fact that the identification of peaks (or modes) is quite difficult when the cohorts overlap, especially in older age groups. Moreover, the occurrence in the samples of fishes longer than L_∞ leads to an overestimation of L_∞ and underestimation of *k*, since both parameters are strongly correlated (Isaac, 1990). Hampton and Majkowski (1987b) showed that elimination of the largest length classes from original length data slightly improves the estimates. Additionally, the deterministic nature of the VBGF is certainly the principal source of error in *k*. The solution will be the implementation of a stochastic model for all the methods used in growth studies. Factors such as seasonal changes in growth rate, variable recruitment period, size-dependent selection, or data grouped in greater length class intervals do not essentially change the tendency of the bias of L_∞ and *k* in ELEFAN I. Because seasonal oscillations in growth are expected to be very frequent in natural populations, the oscillating version of the VBGF can be used in conjunction with the ELEFAN I method. Combination of growth variability and the effect produced by size-dependent selection reduce the accuracy of the growth parameter estimates (particularly *k*) obtained with ELEFAN I. Estimates of L_∞ are not strongly biased by the influence of these factors. Size-dependent selection effects and recruitment processes eliminate slow-growing fishes (i.e. the smallest ones) from the first cohort in samples. Therefore, the difference between the modal lengths of the first and second cohorts is smaller in the samples than the true size difference in the natural population. This leads to the computation of a smaller annual growth rate and therefore an underestimation of *k* (Isaac, 1990).

The SLCA method is also affected by variability among individuals. The bias in *k* increases with increasing coefficients of variation of this parameter, as reported by Isaac (1990) and Basson *et al.* (1988). However, this tendency is reversed when only L_∞ or both L_∞ and *k* vary among individuals. With SLCA the estimates of *k* are relatively accurate (bias $\leq$ 10%), but L_∞ is more strongly overestimated than in ELEFAN I (Isaac, 1990). The truncation of the last length classes may improve the results (Hampton and Majkowski, 1987b). Another critical factor relevant to this method is variability in recruitment time. A long recruitment period produces positive bias in k, as observed by Isaac (1990) and Basson *et al.* (1988). A similar bias is also produced b seasonal growth oscillations (Isaac, 1990). These factors affect cohort structure, and modes can be obscured to such an extent that SLCA method attempts to interpret the entire distribution as representing a single first cohort, overestimating k (Basson *et al.*, 1988). However, it remains unclear why the tendency of this bias is reversed when variability is also assumed for L_∞ and size selection is in operation. Under this circumstances, the same explanation proposed for the ELEFAN I method may be applied, i.e. the occurrence of larger fishes in samples may force the values of L_∞ upwards, provoking an underestimation of k. When small fishes are not well represented in samples but individual variability is very low, SLCA method estimates of L_∞ and k are less biased than those obtained using ELEFAN I. SLCA method frequently shows a tendency to generate multiple maxima of the score function. This phenomenon is most pronounced in populations having the highest variability or the most complicated structure. This constitutes a significant disadvantages of SLCA method, and although multiple maxima also occur in ELEFAN I results, it was generally easier to find the best parameter combination with the latter method (Isaac, 1990).

According to Wetherall *et al.* (1987), the regression method to estimate L_∞ and Z/k should be insensitive to individual variability, since the estimates are based on mean length (L_i). However, these authors tested the method on data without variability. Isaac (1990) showed that individual variability of growth parameters is critical for the estimates of P-W method. The presence of larger fishes in samples leads to higher mean length values, especially at the end of the distribution, producing a moderate slope in the regression line and decreasing the absolute value of β. As a result, values of L_∞ and Z/k are systematically inflated. Wetherall *et al.* (1987) recognized that length class interval, and thus the number of classes, should strongly affect the estimates of their method. Isaac (1990) showed that length class intervals affect the estimates of L_∞ only when variability among individuals is high. Laurec and Mesnil (1987) tested the efficiency of the Beverton and Holt (1956) method, from which the P-W method is derived, and found that the differences in the results obtained for different length class widths are considerable only for populations with large values of Z. P-W method should be more efficient if the points for the regression are weighted by covariance matrix A. However, this implies more computation time, and weighing the points by sample size should also perform acceptably (Wetherall *et al.*, 1987). Seasonal oscillations in growth pattern, variable recruitment and size selection in samples also seem to be sources of error, but the resulting bias is lower than that produced by individual variability (Isaac, 1990).

All methods based on the von Bertalanffy curve suffer from multiple optima at harmonic combinations of L_∞ and k (Kleiber and Pauly, 1991), which is not surprising given that a number of alternative fits to length-frequency data will be reasonable statistically. A degree of subjectivity is inevitable in interpreting the GOF response surface: all the methods can generate multiple peaks along ridges of high GOF and simulations show that in some cases a high peak is not the correct answer. The recommended non-parametric approach to length-frequency analysis is to try to find solutions that are robust against the particular method used. If all four non-parametric methods indicate similar peak GOFs, then you can have some confidence in the answers. Where they differ, decisions have to be based on additional knowledge of the species in question.

1. *The far-horizon (rubber tuna) problem*: the far-horizon problem occurs when a good statistical fit is obtained at high L_∞ and k. This fit implies very rapid growth and, by analogy, a k of 2 might correspond to the growth rate of a tuna-shaped rubber balloon inflated rapidly with a tyre pump. This would be an absurdly fast growth rate. A good fit like this would imply that all the bumps and wiggles in the length-frequency data are only noise and there is only one, or few, cohorts present. Cohort slicing, that assigns fish to ages, and examination of the fitted growth curve against data histograms will check out whether the suggested far-horizon fit is realistic. SLCA is especially prone to this problem, and, to avoid it, it is recommended to scale the GOF by dividing by $(L_\infty \bullet k)$. The general remedy for all methods is to beware of far-horizon solutions unless (a) you have good evidence that fish actually grow that fast (some do, e.g. *Coryphaena*), and (b) you are satisfied with the implications shown by cohort slicing.

2. *The near-horizon (bumpy road) problem*: the near-horizon problem occurs when a good statistical fit is obtained at very low or very high L_∞, and low k, where L_∞ is very close to L_{max}. Cohort slicing in these growth values will reveal many age classes. A good fit here implies that every little bump and wiggle in the length-frequency distribution is a cohort, meaning an absurdly slow growth rate. The only remedy is to beware of solutions which are very close to L_{max} and to examine the implications with cohort slicing. In general k values less than 0.05 are suspect, but of course this can mask growth rates of fish that are long-lived and genuinely slow growing such as sharks, orange roughy (*Hoplostethus atlanticus*), Pacific rockfish (*Sebastes* spp.) or sturgeon (*Acipenseridae*).

3. *General approach to multiple optima*: it is not always easy to choose one from a set of many GOF peaks, especially if you get them from different methods. In the last resort you may have to retain several peaks right through to the assessment stage and examine the management implication of each one. Additional information can be brought to bear upon the problem. For example, one can look at the implications for age structure of alternative peaks using cohort slicing, or otolith or scale readings of sub-samples (Pitcher, 2002).

A powerful general approach is to filter the results using data from similar species that have been analysed elsewhere. Pauly and Munro (1984) demonstrated what they termed an "auximetric" relationship, "Phi prime", between L_∞ and k that is consistent across species:

$$\Phi' = \log k + 2\log L_\infty \qquad (40)$$

Analysis of thousands of such relationships shows that members of a taxon have closely similar auximetric ratios, and so plotting published values of $\log L_\infty$ against $\log k$ can be a good guide to the accuracy of estimates from length-frequency analysis.

2. OBJECTIVES

Growth studies are an essential instrument in the management of fisheries resources because they contribute to estimates of production, stock size, recruitment and mortality of fish populations (Isaac, 1990). For this reason, reliable estimates of the growth and mortality parameters of exploited fish populations are very important for their proper management (Pauly *et al.*, 1984).

In the event that age becomes too complex to be established through an observationof hard parts (otoliths, scales, opercula, rays, spines and vertebrae), information about the demographic parameters of fish and other animal populations can be obtained by length-frequency analysis. Length-frequency distributions are commonly analyzed by means of histograms, although they present several problems, e.g. a dependency on the origin, width and number of class intervals, discontinuity of data and fixed bandwidth (Chambers *et al.*, 1983; Silverman, 1986; Fox, 1990; Scott, 1992). This can largely affect the reliability of the estimates making the results dependent upon the data massage operated by the user.

This research study aims:

- to contribute to overcome some of the above-mentioned limits,
- to test the efficiency of two algorithms with fish length datasets,
- to contribute to produce more accurate estimates of fish growth parameters due to their central position in the fish stock assessment process.

In particular, the first tested algorithm has recently been proposed by Birgé and Rozenholc for determining the optimal number of bins from the available data. The second, the Expectation-Maximization (EM) algorithm, has become a popular tool in statistical computations involving incomplete data, or in similar problems, such as mixture estimation.

3. MATERIALS AND METHODS

The Birgé and Rozenholc algorithm

As stated in the introductory chapter, the number of classes in a histogram is a crucial parameter. Various attempts have been made in the past to solve the problem of determining the optimal number of intervals from the available data. Generally these methods are based on a number of asymptotic considerations. The problem with this approach is that these methods do not perform very well in the case of small sized samples due to their asymptotic nature. Moreover, many of these methods assume some prior information about the density.

Recently, Birgé and Rozenholc (2002) have proposed a new fully automatic and easy method that allows the user to choose the number of intervals to be used for building a regular histogram from the data. As reported by the authors, the procedure is derived from a mixture of theoretical and empirical arguments; is not based on any smoothness assumptions; works quite well for all kinds of densities, even discontinuous; and sample sizes as small as 25. The estimator proposed is a generalization of Akaike's theorem, a statistical measure for model selection which states that if two models fit the data equally well, the simpler model will usually predict better. Below is a brief summary of Birgé and Rozenholc's method of determining the optimal number of intervals of the histograms. For the theoretical arguments underlying the algorithm, refer to Birgé and Rozenholc (2002).

The purpose is to find a histogram estimator $\hat{f}$ based on some partition $\{I_1, \ldots, I_D\}$ of [0,1] into D intervals of equal length. $X_1, X_2, \ldots, X_n$ are n samples from the unknown density f we want to estimate. D is given by

$$D = \arg\max_D (L_n(D) - penalty(D)) \qquad (41)$$

where $L_n(D)$ is the log-likelihood of the histogram with D bins, given by

$$L_n(D) = \sum_{J=1}^{D} M_j \log\left(\frac{DM_j}{n}\right) \qquad (42)$$

with

$$M_j = \sum_{i=1}^{n} \mathbf{1}_{I_j}(X_i) \qquad (43)$$

The penalty function is given by

$$penalty(D) = D - 1 + (\log(D))^{2.5} \qquad \text{for } D \geq 1 \qquad (44)$$

This approach is thus a typical example of model selection methods, making a compromise between the complexity of the model and its fidelity to the data.

For the present study a code in Scilab 4.0 was written to run the Birgé and Rozenholc algorithm (refer to section 8.1 in Appendix A for the listing of the pseudocode).

Scilab is a scientific software package for numerical computations providing a powerful open computing environment for engineering and scientific applications. It was developed at INRIA (*Institut National de Recherche en Informatique et en Automatique*, France) and uses an interactive graphical environment combined with a higher level programming language. The Scilab language can be interfaced easily with C or FORTRAN programs using dynamic links, through the link primitive, or using interfacing or gateway programs (Gomez, 1999).

The Expectation-Maximization algorithm

The Expectation-Maximization (EM) algorithm (Hartley, 1958; Dempster *et al.*, 1977) is an efficient iterative procedure used to compute the Maximum Likelihood (ML) estimate in the presence of missing or hidden data or in problems which can be posed in a similar form, such as mixture estimation (Redner and Walker, 1984; Tanner, 1996; McLachlan and Krishnan, 1997; McLachlan and Peel, 1997; Minka, 1998; Neal and Hinton, 1998). The ML estimation calculates an estimate of the model parameter(s) for which the observed data are the most likely.

Each iteration of the EM algorithm consists of two processes: the E-step and the M-step. In the expectation, or E-step, the missing data are estimated given the observed data and current estimate of the model parameters. This is achieved using the conditional expectation, explaining the choice of terminology. In the maximization, or M-step, the likelihood function is maximized under the assumption that the missing data are known. The estimate of the missing data from the E-step are used instead of the actual missing data. Convergence is assured since the algorithm is guaranteed to increase the likelihood at each iteration.

If, for example, the data can be modelled as a mixture of two normally distributed populations, as occurs in many ecological and environmental studies (Ford, 1975; Sewell and Young, 1997; Skilbrei *et al.*, 1997; Tkadlec and Zejda, 1998), the density function of this mixture model is:

$$f(x;\theta) = \pi f(x;\mu_1,\sigma_1) + (1-\pi) f(x;\mu_2,\sigma_2) \tag{45}$$

where $x = x_1,\ldots,x_n$ are the n observations in the dataset and $\theta = (\mu_1, \mu_2, \sigma_1, \sigma_2, \pi)$ are the model parameters. $f(\cdot)$ is the normal density function with mean, μ_i, and standard deviation, σ_i, where $i = 1$ for the first population and $i = 2$ for the second one (Everitt and Hand, 1981). π is the mixing parameter. Ideally, a likelihood equation is derived from equation (45) and maximized for parameter estimation. However, for this model, the likelihood equation is unbounded and may have multiple roots, so a maximum likelihood may not exist (McLachlan and Basford, 1988). Instead, the parameters of the mixture model may be solved using numerical optimization.

For the mixture model, the EM algorithm computes maximum likelihood estimates (MLEs) analytically derived from the mixture model rewritten as a *complete data* problem. The likelihood equation for the complete data problem is:

$$L(y;\theta) = \prod_{1=1}^{n} (\pi f(x_i,\mu_1,\sigma_1))^{z_i} ((1-\pi) f(x_i,\mu_2,\sigma_2))^{1-z_i} \tag{46}$$

where the complete dataset, y, is the set which includes data that are observable, x, and data that are not observable (or latent), z. θ is equivalent to the parameter vector described for equation (45). For the mixture model, an unobservable datum, z_i, indicates whether an observation, x_i, is from the first or the second population.

In order to start the optimization, the EM algorithm calculates the conditional expectations of the unobservable data using the starting parameter estimates, the values supplied to EM, and the observed data. These expected values are then used in the analytical solutions of the MLEs, which result in new parameter estimates. These new estimates are used in the conditional expectations to calculate new expected values for the unobservable data. This sequence of expectation and maximization continues until convergence. The algorithm converges when iterative changes in the parameter estimates fall below a tolerance level (= 0.00001) or a maximum number of iterations has been performed (= 50) (Turley and Ford, 2000, Nityasuddhi and Böhning, 2003).

During the present study, a code in Scilab 4.0 was written to run the mixture model with EM (refer to section 8.2 in Appendix A for the listing of the pseudocode).

Simulated data

In order to determine the accuracy of vital parameter estimates obtained with a given growth assessment method, the actual or theoretical value of these parameters in the population should be known. This enables the calculation of the difference between their real value and the values obtained by applying the method in question.

However, if a naturally-occurring fish population is taken into consideration, the true values for the vital parameters are unknown. Therefore, a straightforward procedure to analyze the efficiency of any method is to create (or simulate) a hypothetical population, with known characteristics which should be as similar as possible to those of natural populations. A set of data (for example length data) can then be extracted for the desired analysis. The difference between simulated and calculated values (in this case growth parameter values) provides a measurement of the accuracy of the method, i.e. the bias of the method.

This approach belongs to the so-called Monte-Carlo methods (Halton, 1970, Hilborn and Mangel, 1997). In summary, a Monte-Carlo procedure tests the ability of certain methods to describe the underlying structure of a simulated dataset, and thus makes it possible to predict the conditions under which a method will be successful or will fail in performing research studies concerning natural populations.

An advantage of using such an artificial population is that as many datasets as required may be created. A wide range of population "types" can be obtained by varying biological features of the model (Hampton and Majkowski, 1987a,b; Jones, 1987; Castro and Erzini, 1988; Erzini, 1990; Isaac, 1990).

Generation of hypothetical populations

The first step of the present work was to simulate hypothetical populations with known demographic parameters, from which datasets for the following analysis could be extracted.

A code in Scilab 4.0 was thus written to generate the data samples (refer to section 8.3 in Appendix A for the listing of the pseudocode). The development of the program for the generation of the hypothetical populations was guided by one assumption which is implicit in the length-frequency methods: the length distribution for each age class follows a normal distribution.

The values of the following demographic parameters were required for the generation of the hypothetical populations:

- the three parameters (L_∞, k and t_0) of the von Bertalanffy growth function,
- the mean lengths-at-age and the standard deviations,
- the number of cohorts,
- the instantaneous total or natural mortality rate (Z or M).

Choice of parameters

Since a particular method may be better suited for the investigation of certain population types (Isaac, 1990), two marine species were chosen as representatives of opposing life-histories: the Red mullet (*Mullus barbatus* Linnaeus, 1758), a fast-growing species, and the European hake (*Merluccius merluccius* (Linnaeus, 1758)), a slow-growing species. Tables 3.1 and 3.2 show the values of the demographic parameters used in the generation of the hypothetical populations of the two species.

Table 3.1 Input data used in the generation of the Red mullet hypothetical population

Cohort	Mean length (cm)	Standard deviation (cm)
1	7.60	0.65
2	12.12	0.90
3	15.14	1.15
4	17.19	1.4
5	18.37	1.65
6	19.57	1.90
7	20.88	2.15
L_∞ (cm)	20.95	-
k (year^{-1})	0.47	-
t_0 (year)	-0.70	-
M(year^{-1})	0.45	-

Table 3.2 Input data used in the generation of the European hake hypothetical population

Cohort	Mean length (cm)	Standard deviation (cm)
1	19.39	1.44
2	27.08	1.94
3	32.90	2.32
4	39.88	2.78
5	47.14	3.25
6	53.67	3.68
7	62.00	4.22
L_∞ (cm)	63.20	-
k (year^{-1})	0.15	-
t_0 (year)	-0.37	-
M (year^{-1})	0.27	-

Starting from the above demographic parameters, a length sample of size n = 100,000 was generated for each species.

The Birgé and Rozenholc algorithm

Sub-sampling and data partition

In order to evaluate the performance of the Birgé and Rozenholc algorithm using samples of different sizes, 100 random datasets containing 100, 200, 500 and 1000 length measurements respectively were extracted from each hypothetical population.

Data for each of these 800 length datasets was then partitioned using (i) the method proposed by Birgé and Rozenholc (2002) and (ii) the classical interval widths (1 cm for the Red mullet and 2 cm for the European hake). Following the above procedure, 1600 length-frequency distributions were simulated.

During the present study, a code in Scilab 4.0 was written for the sub-sampling and data partition steps (refer to section 8.4 in Appendix A for the listing of the pseudocode).

Length-frequency analysis

The above simulated length-frequency distributions were then analyzed by means of length-frequency methods.

Two techniques were chosen to represent length-frequency analysis: the ELEFAN I method (Brey and Pauly, 1986), a non-parametric approach, and the Bhattacharya method (Bhattacharya, 1967), a parametric approach.

As seen in section 1.2.4.5.2.1 of the introductory chapter, when using the ELEFAN I method, the length-frequency are reconstructed in order to emphasize peaks. Growth curves are generated for values of k and L_∞ within specified ranges and fit the reconstructed length-frequency data. The best curves are considered to be the ones that pass through the most peaks and the least troughs.

In the present study, the two von Bertalanffy growth parameters L_∞ and k were calculated using the ELEFAN I method for each of the 1600 length-frequency distributions. The objective of this experiment was to estimate growth parameters for the same length datasets, but grouping the frequencies by following two different approaches, i.e. Birgé and Rozenholc and the classical partition.

The Bhattacharya method is a technique used to separate normal curves, under the assumption that the length distributions for each age are normal. The decomposition of each length-frequency sample into component distributions is carried out by plotting a logarithmic transformation of the differences between successive length-frequencies. A normal distribution appears as a series of values making up a straight line with a negative slope.

Even in this case the same length datasets, grouped with the two above-mentioned approaches, were analyzed by means of the Bhattacharya method with the aim to evaluate the optimum grouping of data. In this context, the optimum grouping is that partition or interval size which results in the most successful separation of component mixtures and estimation of the mean lengths-at-age and the standard deviations. The optimum grouping of data can be judged on the basis of the correct identification of the number of components or age classes in a distribution and on the precision of the estimated means and standard deviations (Erzini, 1990).

For the present study, a Scilab 4.0 version of the ELEFAN I method and of the Bhattacharya method was developed. The listing of the pseudocodes is given in Appendix A (sections 8.5 and 8.6). In particular, since the results of the Bhattacharya method are often dependent on the person who actually performs the analysis (Sparre and Venema, 1998), a modification of this method was made so that its implementation became fully automated and the estimation of mean lengths-at-age and standard deviations did not require any interaction on behalf of the user.

Pauly and Caddy (1985) have developed a slightly different version of the Bhattacharya method for use with a programmable calculator. Their version was an attempt to turn the Bhattacharya method into an objective method, i.e. method producing results independent of the person carrying out the analysis. In their version, the authors proposed that the choice of points be based on the correlation coefficients (r) calculated for the regressions of all series of three successive points and a critical value of r. Regressions which did not have a negative slope or did not exceed the critical value for r were rejected.

For this study, the distributions were adjusted for selectivity and this approach was extended to all series of 3, 4, …, 15 successive points at the 95% level critical value of r.

The Expectation-Maximization algorithm

Since starting parameter values need to be supplied to the EM algorithm, the ELEFAN I method was modified in order to have as output the following demographic parameters (refer to section 8.5 in Appendix A for the listing of the pseudocode):

- the three parameters (L_∞, k and t_0) of the von Bertalanffy growth function,
- the mean lengths-at-age and the standard deviations,
- the number of cohorts,
- the instantaneous total or natural mortality rate (Z or M).

The above modifications of the method were necessary since the FiSAT package (Gayanilo *et al.*, 1988, 2002; Gayanilo and Pauly, 1989) only provides the estimates of the two von Bertalanffy growth parameters L_∞ and k.

All the previous demographic parameters were then used as starting values to run the mixture model with EM.

Since the EM algorithm functions best with samples of size *n* greater than 1000, only the 100 random datasets each containing 1000 length measurements, extracted from each hypothetical population, were used to run the algorithm.

The following demographic parameters were obtained as output:

- the three parameters (L_∞, k and t_0) of the von Bertalanffy growth function,
- the mean lengths-at-age and the standard deviations,
- the number of cohorts.

Statistical analysis

Following the estimation of the demographic parameters by the ELEFAN I and the Bhattacharya methods, a measure of the bias was calculated by computing the % difference between the simulation input parameters and the estimated results. Thus:

$$\%\,\text{Bias} = \frac{(\text{Estimated parameter - Input parameter})}{\text{Input parameter}} * 100 \quad (47)$$

The median of the 100 estimates and the corresponding bias of each demographic parameter obtained for each data partition in the four samples was, then, calculated.

Consequently, the Shapiro-Wilk test (Shapiro and Wilk, 1965) was then performed on the percentage bias obtained for each data partition in the four samples. The null hypothesis is that the data are normally distributed.

In the case of datasets not following a normal distribution, two non-parametric tests were performed in order to compare the results obtained from the same datasets grouped using the two above-mentioned approaches: the Mann-Whitney *U* test (Wilcoxon, 1945; Mann and Whitney, 1947) and the two-sample Kolmogorov-Smirnov test (Kolmogorov, 1933; Smirnov, 1936).

The Mann-Whitney U test is a non-parametric statistical significance test for assessing whether the difference in medians between two samples of observations is statistically significant (whether the distribution of the samples overlap less than would be expected by chance). The null hypothesis is that the two samples are drawn from a single population, and therefore that the medians are equal.

The two-sample Kolmogorov-Smirnov test is one of the most useful and general non-parametric methods for comparing the distributions of two samples. The null hypothesis is that the two samples originate from a common distribution.

Statistical tests were carried out using the data analysis package PAST (PAlaeontological STatistics, ver. 1.56) (Hammer and Harper, 2005) and the null hypothesis was rejected for *p*-values less then 0.05.

In the case of the EM algorithm, the above statistical analysis was carried out only for the 100 estimates of each demographic parameter obtained in the sample of size *n* of 1000 length measurements. In addition, the percentage contribution of the EM algorithm in terms of producing more accurate estimates of the demographic parameters was computed for each estimate as:

$$\%\,\mathrm{Variation} = \frac{(\%\,\mathrm{Bias}_{\mathrm{ELEFAN}} - \%\,\mathrm{Bias}_{\mathrm{EM}})}{\%\,\mathrm{Bias}_{\mathrm{ELEFAN}}} * 100 \qquad (48)$$

Real data

The objective of this part of the study was to apply the two algorithms previously used with the simulated data to real data, in order to examine their usefulness in practice.

In this case, the two algorithms were applied to two length datasets: one constituted from 1568 length measurements of Red mullets, the second from 2136 length measurements of European hakes.

These length datasets originated from the natural populations for which the demographic parameters were reported in Tables 3.1 and 3.2. In this experiment, the values for these parameters were used as true values of the natural populations. This in order to determine the accuracy of the estimates obtained using the two proposed algorithms as descried in the sub-sections below.

3.4.1 The Birgé and Rozenholc algorithm

As a first step, the two length datasets were grouped by following both the method proposed by Birgé and Rozenholc (2002) and also by using the classical interval widths (1 cm for the Red mullet and 2 cm for the European hake).

Each length-frequency distribution was then analyzed by means of the two length-frequency methods previously used for the simulated data: the ELEFAN I method and the Bhattacharya method. In the case of the ELEFAN I method, the two von Bertalanffy growth parameters L_∞ and k were calculated as outputs, while with the Bhattacharya method, the mean lengths-at-age and the standard deviations of each component identified in the mixture samples were computed.

A measure of the bias was then calculated for each estimate using equation (47). The optimum grouping was chosen as that partition or interval size which resulted in the best estimate of the previous demographic parameters.

3.4.2 The Expectation-Maximization algorithm

Since the starting parameter values need to be supplied to the EM algorithm, the following demographic parameters were computed by means of the implemented version of the ELEFAN I method:

- the three parameters (L_∞, k and t_0) of the von Bertalanffy growth function,
- the mean lengths-at-age and the standard deviations,
- the number of cohorts,
- the instantaneous total or natural mortality rate (Z or M).

All the previous demographic parameters were then used as starting values to run the mixture model with EM.

Following the estimation of the demographic parameters, a measure of the bias was calculated for each estimate using equation (47). Then, the percentage contribution of the EM algorithm in terms of producing more accurate estimates of the demographic parameters was computed for each estimate using equation (48).

4. RESULTS

4.1 Simulated data

4.1.1 The Birgé and Rozenholc algorithm

4.1.1.1. The ELEFAN I method

The medians of the estimates and the corresponding percentage bias of the two growth parameters (L_∞ and k) obtained for the two data partitions in the four samples extracted from the Red mullet hypothetical population are presented in Table 4.1. The four samples used in this research study consist of 100 datasets containing 100, 200, 500 and 1000 length measurements respectively. Figure 4.1 shows the magnitude of the percentage bias as a function of the sample size (number of length measurements). A table containing all raw data is given in Appendix B (Table B.1a-d).

The estimates of the two growth parameters (L_∞ and k) obtained by means of the ELEFAN I method on the histograms constructed using the Birgé and Rozenholc algorithm always gave a lower percentage bias than those obtained with the classical *1 cm* interval width.

Table 4.1 Medians of the estimates and the corresponding percentage bias of the two growth parameters (L_∞ and k) obtained in the four samples using the two partitions for grouping the Red mullet length data. Refer to Table 3.1 for the input data used in the generation of the Red mullet hypothetical population.

Data partition	Sample size (number of length measurements)	Estimates		% Bias	
		L_∞ (cm)	k (year^{-1})	L_∞	k
Birgé and Rozenholc algorithm	100	18.65	0.65	-10.98	38.30
	200	19.15	0.28	-8.60	-40.40
	500	20.10	0.23	-4.10	-51.10
	1000	20.55	0.23	-1.90	-51.10
1 cm	100	17.00	0.20	-18.85	-57.45
	200	18.00	0.24	-14.10	-48.90
	500	19.50	0.22	-6.90	-53.20
	1000	19.00	0.20	-9.30	-57.40

Fig. 4.1 Percentage bias in the estimation of the two growth parameters (L_∞ and k) as a function of the sample size (number of length measurements). A) Data partition constructed following the Birgé and Rozenholc algorithm. B) Data partition constructed using the classical *1 cm* interval width for the Red mullet.

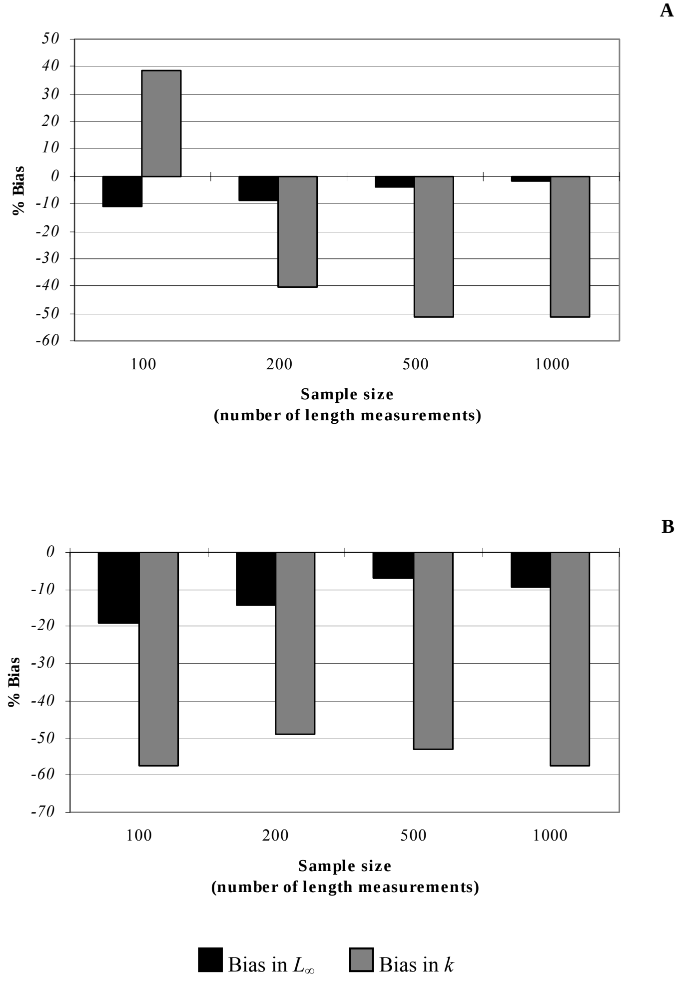

Table 4.2 displays the medians of the class numbers and the corresponding class widths obtained in the four samples for the two data partitions. The class number obtained by grouping the Red mullet length data with the Birgé and Rozenholc algorithm was lower (i.e. a larger class width) than that obtained with the classical *1 cm* interval width for the sub-samplings of 100 and 200 length measurements; the opposite situation (a higher class number and a narrower class width) resulted for the sub-samplings of 500 and 1000 length measurements.

Table 4.2 Medians of the class numbers and the corresponding class widths obtained in the four samples using the two partitions for grouping the Red mullet length data.

Data partition	Sample size (number of length measurements)	*class number*	*class width (cm)*
Birgé and Rozenholc algorithm	100	7.00	2.20
	200	13.00	1.30
	500	24.50	0.75
	1000	32.00	0.59
1 cm	100	16.00	1.00
	200	17.00	1.00
	500	18.00	1.00
	1000	19.00	1.00

Table 4.3 shows the medians of the estimates and the corresponding percentage bias of the two growth parameters (L_∞ and k) obtained for each data partition in the four samples extracted from the European hake hypothetical population. Figure 4.2 shows the magnitude of the percentage bias as a function of the sample size (number of length measurements). A complete list of the results obtained can be found in Appendix B (Table B.2a-d).

The estimates of the two growth parameters (L_∞ and k) obtained by means of the ELEFAN I method on the histograms constructed using the Birgé and Rozenholc algorithm always gave a lower percentage bias than those obtained with the classical *2 cm* interval width. The only exception was the k estimate in the sub-sampling of 100 length measurements.

Table 4.3 Medians of the estimates and the corresponding percentage bias of the two growth parameters (L_∞ and k) obtained in the four samples using the two partitions for grouping the European hake length data. Refer to Table 3.2 for the input data used in the generation of the European hake hypothetical population.

Data partition	Sample size (number of length measurements)	Estimates		% Bias	
		L_∞ (cm)	k (year^{-1})	L_∞	k
Birgé and Rozenholc algorithm	100	59.40	0.01	-6.04	-93.33
	200	76.40	0.08	20.85	-50.00
	500	86.90	0.08	37.46	-46.67
	1000	81.90	0.07	29.55	-53.33
2 cm	100	91.25	0.06	44.34	-60.00
	200	89.25	0.06	41.17	-60.00
	500	89.15	0.06	41.02	-60.00
	1000	97.05	0.06	53.51	-60.00

Fig. 4.2 Percentage bias in the estimation of the two growth parameters (L_∞ and k) as a function of the sample size (number of length measurements). A) Data partition constructed following the Birgé and Rozenholc algorithm. B) Data partition constructed using the classical *2 cm* interval width for the European hake.

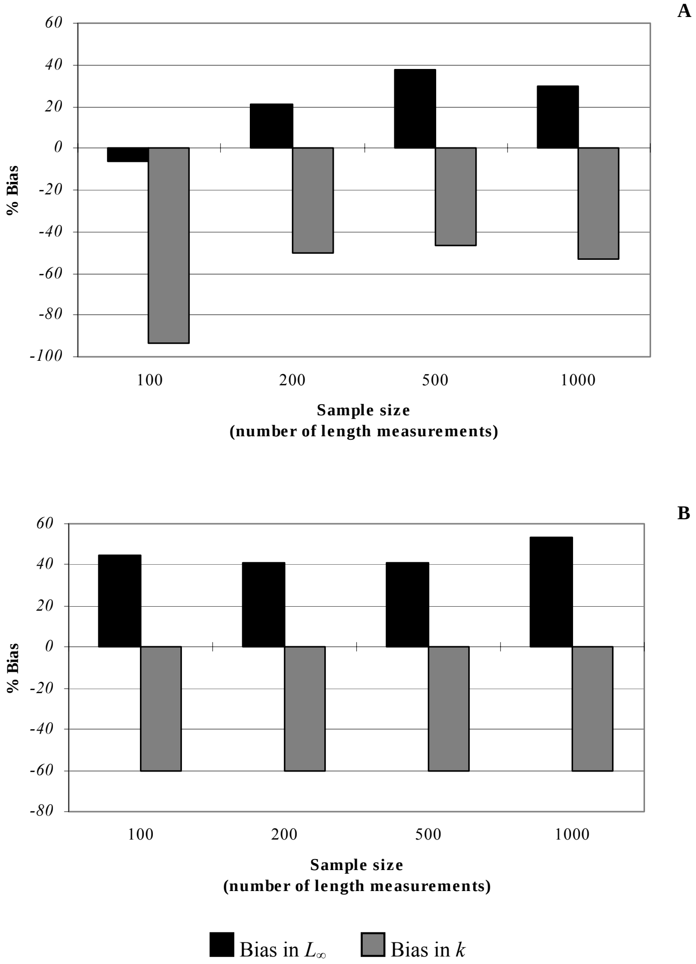

Table 4.4 displays the medians of the class numbers and the corresponding class widths obtained in the four samples for the two data partitions. The class number obtained by grouping the European hake length data with the Birgé and Rozenholc algorithm was lower (i.e. a larger class width) than that obtained with the classical *2 cm* interval width for the sub-samplings of 100, 200 and 500 length measurements; the opposite situation (a higher class number

and a narrower class width) occurred for the sub-sampling of 1000 length measurements.

Table 4.4 Medians of the class numbers and the corresponding class widths obtained in the four samples using the two partitions for grouping the European hake length data.

Data partition	Sample size (number of length measurements)	*class number*	*class width (cm)*
Birgé and Rozenholc algorithm	100	3.00	16.16
	200	10.00	5.33
	500	21.00	2.52
	1000	31.00	1.79
2 cm	100	25.00	2.00
	200	26.00	2.00
	500	27.00	2.00
	1000	28.00	2.00

Table 4.5 reports the results of the Shapiro-Wilk test performed on the percentage bias datasets obtained in the four samples using the two partitions for grouping the Red mullet length data. The percentage bias distributions for both growth parameters did not follow a normal distribution (*p*-values less than 0.05). The exceptions were the sub-samplings of 100, 500 and 1000 length measurements used for estimating the parameter L_∞ and grouped using the Birgé and Rozenholc algorithm.

Table 4.5 Results of the Shapiro-Wilk test performed on the percentage bias datasets obtained in the four samples using the two partitions for grouping the Red mullet length data.

Data partition	Sample size (number of length measurements)	L_∞		k	
		W	p(normal)	W	p(normal)
Birgé and Rozenholc algorithm	100	0.9810	1.584E-01	0.8674	5.530E-08
	200	0.9627	6.269E-03	0.7423	5.877E-12
	500	0.9905	7.038E-01	0.8316	2.619E-09
	1000	0.9825	2.065E-01	0.8629	3.659E-08
1 cm	100	0.8405	5.389E-09	0.6257	1.358E-14
	200	0.8968	1.004E-06	0.8331	2.948E-09
	500	0.9188	1.209E-05	0.8228	1.324E-09
	1000	0.8490	1.094E-08	0.7146	1.200E-12

Table 4.6 reports the results of the Shapiro-Wilk test performed on the percentage bias datasets obtained in the four samples using the two partitions for

grouping the European hake length data. The percentage bias distributions for both growth parameters did not follow a normal distribution (*p*-values less than 0.05).

Table 4.6 Results of the Shapiro-Wilk test performed on the percentage bias datasets obtained in the four samples using the two partitions for grouping the European hake length data.

Data partition	Sample size (number of length measurements)	L_∞		k	
		W	p(normal)	W	p(normal)
Birgé and Rozenholc algorithm	100	0.4206	4.740E-18	0.2671	4.446E-20
	200	0.8663	4.971E-08	0.8362	3.796E-09
	500	0.9143	7.087E-06	0.7716	3.638E-11
	1000	0.9584	3.088E-03	0.7979	2.131E-10
2 cm	100	0.9449	3.881E-04	0.9246	2.483E-05
	200	0.9496	7.800E-04	0.9343	8.768E-05
	500	0.9406	2.112E-04	0.9306	5.416E-05
	1000	0.8861	3.316E-07	0.9533	1.378E-03

Tables 4.7 and 4.8 report the results of the Mann-Whitney and the Kolmogorov-Smirnov tests performed on the percentage bias datasets obtained in the four samples using the two partitions for grouping the Red mullet length data.

As shown in Table 4.7, the medians of percentage bias obtained using the Birgé and Rozenholc algorithm were always statistically different (*p*-values less than 0.05) to those obtained with the classical *1 cm* interval width for both the estimated parameters. The only exception was the sub-sampling of 500 length measurements.

Table 4.7 Results of the Mann-Whitney test performed on the percentage bias datasets obtained in the four samples using the two partitions for grouping the Red mullet length data.

Sample size (number of length measurements)	L_∞		k	
	T	p(same)	T	p(same)
100	2626.0	6.608E-09	1129.0	3.165E-21
200	3442.0	1.415E-04	3143.0	5.696E-06
500	4275.0	7.669E-02	4764.0	5.642E-01
1000	3703.0	1.529E-03	3803.0	3.447E-03

Table 4.8 shows that the percentage bias distributions obtained using the Birgé and Rozenholc algorithm were always statistically different (*p*-values less than 0.05) to those obtained with the classical *1 cm* interval width for both the estimated growth parameters. The only exception was the parameter *k* in the sub-sampling of 500 length measurements.

Table 4.8 Results of the Kolmogorov-Smirnov test performed on the percentage bias datasets obtained in the four samples using the two partitions for grouping the Red mullet length data.

Sample size (number of length measurements)	L_∞		k	
	D	p(same)	D	p(same)
100	0.53	4.2607E-13	0.74	3.9673E-25
200	0.40	1.2116E-07	0.35	5.9565E-06
500	0.25	3.0312E-03	0.06	9.9210E-01
1000	0.46	5.6969E-10	0.27	1.0291E-03

Tables 4.9 and 4.10 report the results of the Mann-Whitney and the Kolmogorov-Smirnov tests performed on the percentage bias datasets obtained in the four samples using the two partitions for grouping the European hake length data.

As shown in Table 4.9, the medians of percentage bias obtained using the Birgé and Rozenholc algorithm were always statistically different (*p*-values less than 0.05) to those obtained with the classical *2 cm* interval width for both the estimated growth parameters. The exception were the parameter L_∞ in the sub-sampling of 500 length measurements and the parameter *k* in the sub-sampling of 200 length measurements.

Table 4.9 Results of the Mann-Whitney test performed on the percentage bias datasets obtained in the four samples using the two partitions for grouping the European hake length data.

Sample size (number of length measurements)	L_∞		k	
	T	p(same)	T	p(same)
100	784.5	7.128E-25	673.0	4.047E-26
200	3573.0	4.912E-04	4616.0	3.487E-01
500	4818.0	6.574E-01	4077.0	2.419E-02
1000	3222.0	1.405E-05	3379.0	7.510E-05

On the other hand, Table 4.10 shows that the percentage bias distributions obtained using the Birgé and Rozenholc algorithm were always statistically different (*p*-values less than 0.05) to those obtained with the classical *2 cm* interval width for both the estimated growth parameters. The exceptions were L_∞ in the sub-sampling of 500 length measurements and *k* in the sub-sampling 100 length measurements.

Table 4.10 Results of the Kolmogorov-Smirnov test performed on the percentage bias datasets obtained in the four samples using the two partitions for grouping the European hake length data.

Sample size (number of length measurements)	L_∞		k	
	D	p(same)	D	p(same)
100	0.82	9.3047E-31	0.93	1.0000E+00
200	0.39	2.7524E-07	0.45	1.4660E-09
500	0.13	3.4389E-01	0.21	2.0495E-02
1000	0.37	1.3347E-06	0.28	5.8125E-04

4.1.1.2. The Bhattacharya method

The medians of the estimates and the corresponding percentage bias of the mean lengths-at-age and the standard deviations obtained for both data partitions in the four samples extracted from the Red mullet hypothetical population are presented in Tables 4.11, 4.12, 4.13 and 4.14. The tables containing all values are given in Appendix B (Tables B.3a-d, B.4a-d, B.5a-d and B.6a-d).

The estimates of the mean lengths-at-age obtained by means of the Bhattacharya method on the histograms constructed using the Birgé and Rozenholc algorithm always gave a lower percentage bias than those obtained with the classical *1 cm* interval width (Tables 4.11 and 4.13). The exception was the first mean length-at-age in the sub-samplings of 100 and 200 lengths measurements.

The estimates of the standard deviations obtained using the Birgé and Rozenholc algorithm always gave a lower percentage bias than those obtained with the classical *1 cm* interval width, except for the first and the second standard deviation in the sub-sampling of 100 lengths measurements (Tables 4.12 and 4.14).

Table 4.11 Medians of the estimates of the mean lengths-at-age obtained in the four samples using the two partitions for grouping the Red mullet length data. Refer to Table 3.1 for the input data used in the generation of the Red mullet hypothetical population.

Data partition	Sample size (number of length measurements)	Estimates						
		mean 1 (cm)	*mean 2 (cm)*	*mean 3 (cm)*	*mean 4 (cm)*	*mean 5 (cm)*	*mean 6 (cm)*	*mean 7 (cm)*
Birgé and Rozenholc algorithm	100	12.71	14.42	15.75	-	-	-	-
	200	11.35	12.04	15.15	17.33	19.73	1.04	-
	500	7.21	11.77	15.22	17.25	18.81	20.06	19.94
	1000	7.29	11.75	15.10	16.99	18.93	19.80	20.97
1 cm	100	7.31	7.85	11.70	12.31	12.15	13.29	-
	200	6.90	7.51	8.21	11.72	12.35	13.15	14.10
	500	6.62	7.23	7.83	8.87	11.14	11.69	12.32
	1000	6.43	7.28	7.97	9.03	10.78	11.37	12.11

Table 4.12 Medians of the estimates of the standard deviations obtained in the four samples using the two partitions for grouping the Red mullet length data. Refer to Table 3.1 for the input data used in the generation of the Red mullet hypothetical population.

Data partition	Sample size (number of length measurements)	Estimates						
		SD 1 (cm)	*SD 2 (cm)*	*SD 3 (cm)*	*SD 4 (cm)*	*SD 5 (cm)*	*SD 6 (cm)*	*SD 7 (cm)*
Birgé and Rozenholc algorithm	100	2.50	2.16	1.34	-	-	-	-
	200	1.04	1.17	1.43	1.27	1.10	-	-
	500	0.68	0.90	1.33	1.20	0.91	0.83	0.82
	1000	0.65	0.86	1.34	1.10	0.96	0.74	0.57
1 cm	100	0.12	0.11	0.12	0.09	0.12	0.19	-
	200	0.12	0.13	0.12	0.12	0.12	0.12	0.12
	500	0.13	0.17	0.17	0.13	0.12	0.12	0.14
	1000	0.14	0.26	0.20	0.13	0.13	0.15	0.17

Table 4.13 Medians of the percentage bias of the mean lengths-at-age obtained in the four samples using the two partitions for grouping the Red mullet length data. Refer to Table 3.1 for the input data used in the generation of the Red mullet hypothetical population.

Data partition	Sample size (number of length measurements)	% Bias						
		mean 1	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*mean 7*
Birgé and Rozenholc algorithm	100	67.28	18.92	4.06	-	-	-	-
	200	45.25	-0.80	0.11	0.79	7.43	-	-
	500	-5.10	-2.92	0.59	0.35	2.42	2.53	-4.51
	1000	-4.11	-3.08	-0.24	-1.20	3.10	1.22	0.40
1 cm	100	-3.79	-35.24	-22.67	-28.39	-33.84	-32.07	-
	200	-9.22	-38.05	-45.75	-31.85	-32.75	-32.79	-32.49
	500	-12.90	-40.33	-48.29	-48.44	-39.33	-40.23	-41.03
	1000	-15.35	-39.95	-47.32	-47.48	-41.32	-41.89	-42.00

Table 4.14 Medians of the percentage bias of the standard deviations obtained in the four samples using the two partitions for grouping the Red mullet length data. Refer to Table 3.1 for the input data used in the generation of the Red mullet hypothetical population.

Data partition	Sample size (number of length measurements)	% Bias						
		SD 1	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*	*SD 7*
Birgé and Rozenholc algorithm	100	284.75	140.17	16.75	-	-	-	-
	200	60.33	30.25	24.49	-9.34	-33.32	-	-
	500	4.49	0.49	15.67	-14.52	-44.72	-56.51	-61.73
	1000	-0.77	-4.22	16.35	-21.67	-41.95	-60.87	-73.43
1 cm	100	-82.28	-87.24	-89.56	-93.59	-92.72	-90.19	-
	200	-81.10	-85.20	-89.67	-91.42	-92.72	-93.68	-94.41
	500	-79.26	-80.72	-84.93	-90.81	-92.72	-93.53	-93.52
	1000	-78.07	-71.32	-82.19	-90.36	-91.82	-91.95	-92.28

Table 4.15 reports the median and the maximum number of identified cohorts obtained for the two data partitions in the four samples extracted from the Red mullet hypothetical population. The median and the maximum number of identified cohorts obtained by means of the Bhattacharya method on the histograms constructed using the Birgé and Rozenholc algorithm were always lower than those obtained with the classical *1 cm* interval width. Nevertheless, the use of the classical *1 cm* interval width resulted in an overestimate of the number of cohorts of the Red mullet population, as shown both by the median number of cohorts identified in the sub-samplings of 500 and 1000 length measurements and by the maximum number of cohorts identified in the sub-samplings of 200, 500 and 1000 length measurements. The use of the Birgé and Rozenholc algorithm resulted in an overestimate of the number of cohorts of the Red mullet populations only in the sub-sampling of 1000 length measurements.

Table 4.15 Median and maximum number of identified cohorts obtained in the four samples using the two data partitions for grouping the Red mullet length data.

Data partition	Sample size (number of length measurements)	*median number of identified cohorts*	*maximum number of identified cohorts*
Birgé and Rozenholc algorithm	100	1	3
	200	3	5
	500	4	7
	1000	5	8
1 cm	100	3	6
	200	7	12
	500	14	17
	1000	16	19

The medians of the estimates and the corresponding percentage bias of the mean lengths-at-age and the standard deviations obtained for both data partitions in the four samples extracted from the European hake hypothetical population are presented in Tables 4.16, 4.17, 4.18 and 4.19. The tables containing all values are given in Appendix B (Tables B.7a-d, B.8a-d, B.9a-d and B.10a-d).

The estimates of the mean lengths-at-age obtained using the Birgé and Rozenholc algorithm always gave a lower percentage bias than those obtained with the classical *2 cm* interval width (Tables 4.16 and 4.18). The exceptions were the first and the second mean length-at-age in the sub-sampling of 100 length measurements, the first, the second and the third mean length-at-age in the sub-sampling of 200 length measurements, and the first mean length-at-age in the sub-sampling of 500 length measurements.

The estimates of the standard deviations obtained using the Birgé and Rozenholc algorithm always gave a lower percentage bias than those obtained with the classical *2 cm* interval width (Tables 4.17 and 4.19). The exceptions were the first and the second standard deviation in the sub-samplings of 100 and 200 length measurements, and the first standard deviation in the sub-sampling of 500 length measurements.

Table 4.15 Medians of the estimates of the mean lengths-at-age obtained in the four samples using the two partitions for grouping the European hake length data. Refer to Table 3.2 for the input data used in the generation of the European hake hypothetical population.

Data partition	Sample size (number of length measurements)	Estimates						
		mean 1 (cm)	*mean 2 (cm)*	*mean 3 (cm)*	*mean 4 (cm)*	*mean 5 (cm)*	*mean 6 (cm)*	*mean 7 (cm)*
Birgé and Rozenholc algorithm	100	30.10	50.46	-	-	-	-	-
	200	5.47	8.68	9.80	11.01	11.92	-	-
	500	20.97	27.44	33.61	42.00	49.73	55.26	-
	1000	19.58	26.87	33.05	41.49	50.00	55.70	-
2 cm	100	19.13	27.73	36.15	45.37	51.91	-	-
	200	18.97	26.70	34.83	43.35	51.33	58.37	-
	500	18.92	28.51	36.11	43.12	50.55	58.44	64.58
	1000	18.96	28.28	36.65	43.88	50.64	58.28	65.10

Table 4.16 Medians of the estimates of the standard deviations obtained in the four samples using the two partitions for grouping the European hake length data. Refer to Table 3.2 for the input data used in the generation of the European hake hypothetical population.

Data partition	Sample size (number of length measurements)	Estimates						
		SD 1 (cm)	*SD 2 (cm)*	*SD 3 (cm)*	*SD 4 (cm)*	*SD 5 (cm)*	*SD 6 (cm)*	*SD 7 (cm)*
Birgé and Rozenholc algorithm	100	12.90	4.71	-	-	-	-	-
	200	1.16	1.27	0.95	0.80	0.72	-	-
	500	1.61	2.19	2.75	2.88	3.29	4.09	-
	1000	1.44	2.00	2.41	2.81	3.30	4.00	-
2 cm	100	1.11	1.20	1.10	0.87	1.03	-	-
	200	1.28	1.32	1.19	1.15	1.10	0.85	-
	500	1.37	2.44	1.66	1.42	1.30	1.26	1.20
	1000	1.47	2.31	2.61	1.85	1.61	1.33	1.09

Table 4.17 Medians of the percentage bias of the mean lengths-at-age obtained in the four samples using the two partitions for grouping the European hake length data. Refer to Table 3.2 for the input data used in the generation of the European hake hypothetical population.

Data partition	Sample size (number of length measurements)	% Bias						
		mean 1	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*mean 7*
Birgé and Rozenholc algorithm	100	55.25	86.34	-	-	-	-	-
	200	8.19	12.06	9.79	7.60	5.28	-	-
	500	8.13	1.33	2.17	5.81	5.50	2.97	-
	1000	-0.98	-0.79	0.47	4.03	6.08	3.79	
2 cm	100	-1.32	2.39	9.88	13.75	10.12	-	-
	200	-2.14	-1.40	5.85	8.69	8.89	8.75	-
	500	-2.44	-5.29	9.79	8.14	7.24	8.90	4.15
	1000	-2.24	4.42	10.01	10.04	7.41	8.58	5.00

Table 4.18 Medians of the percentage bias of the standard deviations obtained in the four samples using the two partitions for grouping the European hake length data. Refer to Table 3.2 for the input data used in the generation of the European hake hypothetical population.

Data partition	Sample size (number of length measurements)	% Bias						
		SD 1	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*	*SD 7*
Birgé and Rozenholc algorithm	100	795.96	142.94	-	-	-	-	-
	200	60.78	45.27	20.84	8.95	2.22	-	-
	500	11.75	13.33	18.60	3.65	-1.13	-11.13	-
	1000	0.14	3.16	3.76	1.02	-1.45	-8.81	-
2 cm	100	-22.59	-38.09	-52.77	-68.59	-68.41	-	-
	200	-11.01	-31.91	-48.67	-58.52	-66.19	-76.92	-
	500	-4.61	-25.52	-28.26	-48.97	-59.92	-65.78	-71.54
	1000	2.20	19.08	12.64	-33.37	-50.46	-63.80	-74.18

Table 4.20 reports the median and the maximum number of identified cohorts obtained for the two data partitions in the four samples extracted from the European hake hypothetical population. The median and the maximum number of identified cohorts obtained by means of the Bhattacharya method on the histograms constructed using the Birgé and Rozenholc algorithm were always lower than those obtained with the classical *2 cm* interval width. The use of the Birgé and Rozenholc algorithm never resulted in the identification of all seven possible cohorts in the European hake populations. Moreover, the number (median and maximum) of identified cohorts was particularly low in the sub-sampling of 100 length measurement and, only with reference to the median number, in the sub-sampling of 200 length measurements.

Table 4.20 Median and maximum number of identified cohorts obtained in the four samples using the two partitions for grouping the European hake length data.

Data partition	Sample size (number of length measurements)	*median number of identified cohorts*	*maximum number of identified cohorts*
Birgé and Rozenholc algorithm	100	0	2
	200	1	5
	500	4	6
	1000	4	6
2 cm	100	3	5
	200	5	6
	500	6	7
	1000	6	7

Tables 4.21 and 4.22 report the results of the Shapiro-Wilk test performed on the percentage bias datasets obtained by estimating the mean lengths-at age and the standard deviations in the four samples using the two partitions for grouping the

Red mullet length data. Most percentage bias distributions did not follow a normal distribution (*p*-values less than 0.05).

Tables 4.23 and 4.24 report the results of the Shapiro-Wilk test performed on the percentage bias datasets obtained by estimating the mean lengths-at age and the standard deviations in the four samples using the two partitions for grouping the European hake length data. Most percentage bias distributions did not follow a normal distribution (*p*-values less than 0.05).

Tables 4.25 and 4.26 report the results of the Mann-Whitney and the Kolmogorov-Smirnov tests performed on the percentage bias datasets obtained by estimating the mean lengths-at age in the four samples using the two partitions for grouping the Red mullet length data.

As shown in Table 4.25, the medians of the percentage bias obtained using the Birgé and Rozenholc algorithm were always statistically different (*p*-values less than 0.05) to those obtained with the classical *1 cm* interval width. On the other hand, Table 4.26 shows that the percentage bias distributions obtained using the Birgé and Rozenholc algorithm were always statistically different (*p*-values less than 0.05) to those obtained with the classical *1 cm* interval width. The exceptions were the second, the third and the fourth mean length-at-age in the sub-sampling of 500 length measurements, and the first, the second, the third, the fourth and the fifth mean length-at-age in the sub-sampling of 1000 length measurements.

Tables 4.27 and 4.28 report the results of the Mann-Whitney and the Kolmogorov-Smirnov tests performed on the percentage bias datasets obtained by estimating the standard deviations in the four samples using the two partitions for grouping the Red mullet length data.

As shown in Table 4.27, the medians of the percentage bias obtained using the Birgé and Rozenholc algorithm were always statistically different (*p*-values less than 0.05) to those obtained with the classical *1 cm* interval width. On the other hand, Table 4.28 shows that the percentage bias distributions obtained using the Birgé and Rozenholc algorithm were always statistically different (*p*-values less than 0.05) to those obtained with the classical *1 cm* interval width.

Table 4.21 Results of the Shapiro-Wilk test performed on the percentage bias datasets obtained by estimating the mean lengths-at-age in the four samples using the two partitions for grouping the Red mullet length data.

Data partition	Sample size (number of length measurements)	*mean 1*		*mean 2*		*mean 3*		*mean 4*		*mean 5*		*mean 6*		*mean 7*	
		W	p(normal)	W	p(normal)	W	p(normal)	W	p(normal)	W	p(normal)	W	p(normal)	W	p(normal)
Birgé and Rozenholc algorithm	100	0.8748	2.201E-07	0.9638	5.203E-01	0.8386	9.651E-02	-	-	-	-	-	-	-	-
	200	0.8196	1.041E-09	0.8411	1.956E-07	0.9430	1.362E-02	0.9650	3.936E-01	0.9961	8.802E-01	-	-	-	-
	500	0.2414	2.195E-20	0.5321	2.616E-16	0.9469	6.522E-04	0.9671	4.545E-02	0.9831	8.330E-01	0.8890	1.145E-01	0.8632	2.765E-01
	1000	0.9867	4.166E-01	0.6598	6.867E-14	0.8249	1.558E-09	0.9867	4.711E-01	0.9885	7.293E-01	0.9840	8.799E-01	0.8858	4.787E-02
1 cm	100	0.5208	2.042E-16	0.6145	2.386E-13	0.8637	1.241E-05	-	-	-	-	-	-	-	-
	200	0.9673	1.382E-02	0.6188	9.940E-15	0.7455	7.110E-12	0.8826	2.615E-07	0.8718	1.322E-07	-	-	-	-
	500	0.9837	2.545E-01	0.9673	1.383E-02	0.6384	2.455E-14	0.8601	2.857E-08	0.9320	6.492E-05	0.9044	2.302E-06	0.8682	5.955E-08
	1000	0.9521	1.150E-03	0.9927	8.682E-01	0.8632	3.753E-08	0.8814	2.079E-07	0.9272	3.468E-05	0.9849	3.148E-01	0.9852	3.267E-01

Table 4.22 Results of the Shapiro-Wilk test performed on the percentage bias datasets obtained by estimating the standard deviations in the four samples using the two partitions for grouping the Red mullet length data.

Data partition	Sample size (number of length measurements)	*SD 1*		*SD 2*		*SD 3*		*SD 4*		*SD 5*		*SD 6*		*SD 7*	
		W	p(normal)	W	p(normal)	W	p(normal)	W	p(normal)	W	p(normal)	W	p(normal)	W	p(normal)
Birgé and Rozenholc algorithm	100	0.9798	1.557E-01	0.9157	4.697E-02	0.9339	5.843E-01	-	-	-	-	-	-	-	-
	200	0.8530	1.538E-08	0.8328	1.081E-07	0.8902	1.527E-04	0.9678	4.797E-01	0.9725	6.816E-01	-	-	-	-
	500	0.6398	2.618E-14	0.8267	1.782E-09	0.8378	6.349E-09	0.9167	1.002E-04	0.8330	6.483E-05	0.9451	5.825E-01	0.8632	2.765E-01
	1000	0.9818	1.873E-01	0.9609	4.659E-03	0.7991	2.316E-10	0.9066	5.957E-06	0.9228	1.913E-04	0.9316	2.803E-02	0.9646	7.455E-01
1 cm	100	0.8682	6.687E-08	0.9390	7.168E-04	0.9470	1.445E-02	-	-	-	-	-	-	-	-
	200	0.6825	2.149E-13	0.6852	2.467E-13	0.9289	4.290E-05	0.9488	7.427E-04	0.9070	4.574E-06	-	-	-	-
	500	0.8122	5.993E-10	0.5506	5.429E-16	0.7150	1.225E-12	0.6770	1.621E-13	0.5422	3.892E-16	0.7393	4.934E-12	0.7745	4.395E-11
	1000	0.8634	3.837E-08	0.8332	2.977E-09	0.9091	3.887E-06	0.8199	1.065E-09	0.5363	3.082E-16	0.6770	1.619E-13	0.6564	5.809E-14

Table 4.23 Results of the Shapiro-Wilk test performed on the percentage bias datasets obtained by estimating the mean lengths-at-age in the four samples using the two partitions for grouping the European hake length data.

Data partition	Sample size (number of length measurements)	*mean 1*		*mean 2*		*mean 3*		*mean 4*		*mean 5*		*mean 6*		*mean 7*	
		W	p(normal)	W	p(normal)	W	p(normal)	W	p(normal)	W	p(normal)	W	p(normal)	W	p(normal)
Birgé and Rozenholc algorithm	100	0.9641	8.318E-01	0.9356	6.280E-01	-	-	-	-	-	-	-	-	-	-
	200	0.7562	2.313E-08	0.9692	2.460E-01	0.9620	5.308E-01	0.8574	1.803E-01	0.5762	3.213E-08	-	-	-	-
	500	0.7477	8.147E-12	0.9019	2.630E-06	0.9758	1.608E-01	0.9745	3.127E-01	0.9813	9.268E-01	0.9400	6.661E-01	-	-
	1000	0.3976	2.226E-18	0.7920	1.889E-10	0.9773	1.020E-01	0.9627	1.963E-02	0.9268	5.771E-02	0.8641	2.432E-01	-	-
2 cm	100	0.6543	5.242E-14	0.7821	8.361E-11	-	-	-	-	-	-	-	-	-	-
	200	0.4441	1.047E-17	0.7677	2.828E-11	0.8336	3.068E-09	0.8980	1.932E-06	0.9023	2.691E-05	-	-	-	-
	500	0.9666	1.227E-02	0.7431	6.187E-12	0.8156	7.689E-10	0.8558	1.956E-08	0.8552	1.860E-08	0.9595	1.111E-02	-	-
	1000	0.2514	6.079E-01	0.6079	6.108E-15	0.7755	4.686E-11	0.8278	1.945E-09	0.8597	3.115E-08	0.9314	1.085E-04	-	-

Table 4.24 Results of the Shapiro-Wilk test performed on the percentage bias datasets obtained by estimating the standard deviations in the four samples using the two partitions for grouping the European hake length data.

Data partition	Sample size (number of length measurements)	*SD 1*		*SD 2*		*SD 3*		*SD 4*		*SD 5*		*SD 6*		*SD 7*	
		W	p(normal)	W	p(normal)	W	p(normal)	W	p(normal)	W	p(normal)	W	p(normal)	W	p(normal)
Birgé and Rozenholc algorithm	100	0.8470	6.913E-02	0.8485	2.214E-01	-	-	-	-	-	-	-	-	-	-
	200	0.8245	1.504E-09	0.7144	1.186E-12	0.5319	2.590E-16	0.2423	2.251E-20	0.0752	3.371E-22	-	-	-	-
	500	0.7778	5.435E-11	0.8285	3.508E-09	0.7999	1.046E-08	0.8554	1.331E-05	0.9718	7.317E-01	0.8240	1.253E-01	-	-
	1000	0.4463	1.130E-17	0.8372	5.327E-09	0.8664	1.032E-07	0.3441	3.656E-17	0.9481	1.928E-01	0.8179	1.124E-01	-	-
2 cm	100	0.9239	2.267E-05	0.9271	3.736E-05	-	-	-	-	-	-	-	-	-	-
	200	0.9231	2.060E-05	0.8541	1.691E-08	0.8600	2.830E-08	0.8962	1.598E-06	0.9445	2.523E-03	-	-	-	-
	500	0.9928	8.787E-01	0.9486	6.741E-04	0.7770	5.157E-11	0.5870	2.454E-15	0.3977	2.233E-18	0.8945	5.708E-06	-	-
	1000	0.9465	4.921E-04	0.8828	2.377E-07	0.8386	4.595E-09	0.5274	2.176E-16	0.8651	5.022E-08	0.7869	2.777E-10	-	-

Table 4.25 Results of the Mann-Whitney test performed on the percentage bias datasets obtained by estimating the mean lengths-at-age in the four samples using the two partitions for grouping the Red mullet length data.

Sample size (number of length measurements)	*mean 1*		*mean 2*		*mean 3*		*mean 4*		*mean 5*		*mean 6*		*mean 7*	
	T	p(same)	T	p(same)	T	p(same)	T	p(same)	T	p(same)	T	p(same)	T	p(same)
100	336.0	9.107E-29	25.0	4.633E-13	7.0	3.628E-05	-	-	-	-	-	-	-	-
200	1203.0	1.754E-20	20.0	4.046E-29	7.0	3.973E-24	11.0	8.749E-17	0.0	3.399E-03	-	-	-	-
500	431.0	6.213E-29	0.0	2.562E-34	0.0	8.091E-34	0.0	7.578E-30	0.0	3.071E-19	0.0	1.704E-08	0.0	3.369E-03
1000	151.5	2.269E-32	32.0	6.681E-34	0.0	2.562E-34	0.0	3.962E-33	0.0	7.578E-30	0.0	1.575E-18	0.0	1.542E-10

Table 4.26 Results of the Kolmogorov-Smirnov test performed on the percentage bias datasets obtained by estimating the mean lengths-at-age in the four samples using the two partitions for grouping the Red mullet length data.

Sample size (number of length measurements)	*mean 1*		*mean 2*		*mean 3*		*mean 4*		*mean 5*		*mean 6*		*mean 7*	
	D	p(same)	D	p(same)	D	p(same)	D	p(same)	D	p(same)	D	p(same)	D	p(same)
100	0.94	1.1425E-38	0.89	4.3906E-14	0.95	6.0436E-06	-	-	-	-	-	-	-	-
200	0.60	1.1514E-16	0.98	2.0849E-37	0.98	9.0419E-31	0.98	2.7734E-21	1.00	1.5777E-03	-	-	-	-
500	0.91	8.8103E-38	1.00	1.0000E+00	1.00	1.0000E+00	1.00	1.0000E+00	1.00	3.5567E-25	1.00	1.2612E-10	1.00	1.5658E-03
1000	0.95	1.0000E+00	0.99	1.0000E+00	1.00	1.0000E+00	1.00	1.0000E+00	1.00	1.0000E+00	1.00	3.2518E-24	1.00	2.1665E-13

Table 4.27 Results of the Mann-Whitney test performed on the percentage bias datasets obtained by estimating the standard deviations in the four samples using the two partitions for grouping the Red mullet length data.

Sample size (number of length measurements)	*SD 1*		*SD 2*		*SD 3*		*SD 4*		*SD 5*		*SD 6*		*SD 7*	
	T	p(same)	T	p(same)	T	p(same)	T	p(same)	T	p(same)	T	p(same)	T	p(same)
100	0.0	3.781E-33	0.0	1.133E-13	0.0	1.864E-05	-	-	-	-	-	-	-	-
200	11.0	3.564E-34	0.0	2.031E-29	0.0	3.018E-24	0.0	1.274E-16	0.0	3.399E-03	-	-	-	-
500	0.0	2.562E-34	110.0	6.735E-33	24.0	1.679E-33	10.0	1.066E-29	14.0	5.673E-19	4.0	7.297E-08	5.0	4.599E-03
1000	0.0	3.744E-34	342.0	5.255E-30	1.0	2.640E-34	1.0	4.087E-33	35.0	2.491E-29	30.0	2.585E-18	34.0	8.849E-10

Table 4.28 Results of the Kolmogorov-Smirnov test performed on the percentage bias datasets obtained by estimating the standard deviations in the four samples using the two partitions for grouping the Red mullet length data.

Sample size (number of length measurements)	*SD 1*		*SD 2*		*SD 3*		*SD 4*		*SD 5*		*SD 6*		*SD 7*	
	D	p(same)	D	p(same)	D	p(same)	D	p(same)	D	p(same)	D	p(same)	D	p(same)
100	1.00	1.0000E+00	1.00	1.1670E-17	1.00	1.4156E-06	-	-	-	-	-	-	-	-
200	0.99	1.0000E+00	1.00	6.2261E-39	1.00	5.9970E-32	1.00	1.2422E-21	1.00	1.5777E-03	-	-	-	-
500	1.00	1.0000E+00	0.96	1.0000E+00	0.97	1.0000E+00	0.96	1.0088E-36	0.98	3.3974E-24	0.97	2.4279E-09	0.95	3.1449E-03
1000	1.00	1.0000E+00	0.83	1.6764E-31	0.99	1.0000E+00	0.99	1.0000E+00	0.98	5.8121E-38	0.98	9.7545E-24	0.94	6.9970E-12

The exceptions were the first standard deviation in the sub-samplings of 100 and 200 length measurements, the first, the second and the third standard deviation in the sub-sampling of 500 length measurements, and the first, the third and the fourth standard deviation in the sub-sampling of 1000 length measurements.

Tables 4.29 and 4.30 report the results of the Mann-Whitney and the Kolmogorov-Smirnov tests performed on the percentage bias datasets obtained by estimating the mean lengths-at-age in the four samples using the two partitions for grouping the European hake length data.

As shown in Table 4.29, the medians of the percentage bias obtained using the Birgé and Rozenholc algorithm were always statistically different (*p*-values less than 0.05) from those obtained with the classical *2 cm* interval width. On the other hand, Table 4.30 shows that the percentage bias distributions obtained using the Birgé and Rozenholc algorithm were always statistically different (*p*-values less than 0.05) from those obtained with the classical *2 cm* interval width, except for the sixth mean length-at-age in the sub-sampling of 500 length measurements.

Tables 4.31 and 4.32 report the results of the Mann-Whitney and the Kolmogorov-Smirnov tests performed on the percentage bias datasets obtained by estimating the standard deviations in the four samples using the two partitions for grouping the European hake length data.

As shown in Table 4.31, the medians of the percentage bias obtained using the Birgé and Rozenholc algorithm were always statistically different (*p*-values less than 0.05) to those obtained with the classical *2 cm* interval width. On the other hand, Table 4.32 shows that the distributions of the percentage bias obtained using the Birgé and Rozenholc algorithm were always statistically different (*p*-values less than 0.05) to those obtained with the classical *2 cm* interval width, except for the third and the fourth standard deviation in the sub-sampling of 200 length measurements.

Table. 4.29 Results of the Mann-Whitney test performed on the percentage bias datasets obtained by estimating the mean lengths-at-age in the four samples using the two partitions for grouping the European hake length data.

Sample size (number of length measurements)	*mean 1*		*mean 2*		*mean 3*		*mean 4*		*mean 5*		*mean 6*		*mean 7*	
	T	p(same)	T	p(same)	T	p(same)	T	p(same)	T	p(same)	T	p(same)	T	p(same)
100	213.0	2.893E-03	4.0	9.566E-04	-	-	-	-	-	-	-	-	-	-
200	75.0	4.165E-24	121.0	2.122E-20	835.0	1.326E-11	51.0	7.948E-04	211.0	2.212E-20	-	-	-	-
500	3965.0	1.148E-02	1442.0	2.734E-17	830.0	1.337E-18	682.0	4.554E-14	274.0	1.355E-08	179.0	6.419E-03	-	-
1000	2067.0	7.696E-13	1515.0	4.591E-17	638.0	2.699E-25	423.0	7.352E-25	178.0	5.783E-12	61.5	5.909E-03	-	-

Table 4.30 Results of the Kolmogorov-Smirnov test performed on the percentage bias datasets obtained by estimating the mean lengths-at-age in the four samples using the two partitions for grouping the European hake length data.

Sample size (number of length measurements)	*mean 1*		*mean 2*		*mean 3*		*mean 4*		*mean 5*		*mean 6*		*mean 7*	
	D	p(same)	D	p(same)	D	p(same)	D	p(same)	D	p(same)	D	p(same)	D	p(same)
100	0.69	1.3844E-04	0.97	3.7287E-04	-	-	-	-	-	-	-	-	-	-
200	0.90	5.3495E-27	0.86	3.5813E-22	0.81	2.2672E-11	0.74	1.7944E-03	0.81	2.2762E-07	-	-	-	-
500	0.55	4.5195E-14	0.68	9.6336E-21	0.71	3.6245E-20	0.69	1.3694E-15	0.67	3.3225E-08	0.26	8.5709E-01	-	-
1000	0.61	3.2764E-17	0.69	6.0810E-22	0.82	1.3055E-29	0.78	1.4300E-24	0.73	8.6368E-11	0.68	1.2650E-02	-	-

Table 4.31 Results of the Mann-Whitney test performed on the percentage bias datasets obtained by estimating the standard deviations in the four samples using the two partitions for grouping the European hake length data.

Sample size (number of length measurements)	*SD 1*		*SD 2*		*SD 3*		*SD 4*		*SD 5*		*SD 6*		*SD 7*	
	T	p(same)	T	p(same)	T	p(same)	T	p(same)	T	p(same)	T	p(same)	T	p(same)
100	0.0	7.466E-07	0.0	7.482E-04	-	-	-	-	-	-	-	-	-	-
200	1229.0	1.770E-18	553.0	1.701E-27	265.0	5.971E-31	100.0	3.749E-32	0.0	1.237E-29	-	-	-	-
500	1797.0	5.078E-15	1863.0	1.394E-13	867.0	3.591E-18	338.0	7.781E-19	25.0	3.005E-13	2.0	2.216E-04	-	-
1000	4999.0	9.990E-03	4535.0	3.659E-02	4485.0	4.831E-02	1460.0	2.659E-13	173.0	4.691E-12	18.0	5.501E-04	-	-

Table 4.32 Results of the Kolmogorov-Smirnov test performed on the percentage bias datasets obtained by estimating the standard deviations in the four samples using the two partitions for grouping the European hake length data.

Sample size (number of length measurements)	*SD 1*		*SD 2*		*SD 3*		*SD 4*		*SD 5*		*SD 6*		*SD 7*	
	D	p(same)	D	p(same)	D	p(same)	D	p(same)	D	p(same)	D	p(same)	D	p(same)
100	1.00	2.0765E-08	1.00	2.1619E-04	-	-	-	-	-	-	-	-	-	-
200	0.75	8.4401E-26	0.92	1.3166E-38	0.97	1.0000E+00	0.99	1.0000E+00	1.00	3.1897E-39	-	-	-	-
500	0.58	1.3361E-15	0.68	7.2230E-21	0.72	1.0043E-20	0.91	1.5731E-26	0.98	4.3191E-17	0.99	4.5102E-05	-	-
1000	0.50	1.0553E-11	0.50	1.3644E-11	0.46	1.1759E-09	0.75	4.8751E-23	0.90	2.9114E-16	0.95	1.0248E-04	-	-

4.1.2 The Expectation-Maximization algorithm

The medians of the estimates and the corresponding percentage bias of the demographic parameters computed by means of the ELEFAN I method and the EM algorithm in the sub-sampling of 1000 length measurements extracted from the Red mullet hypothetical population are presented in Tables 4.33 and 4.34 respectively. Table 4.34 also reports the percentage contribution of the EM algorithm (% variation) in terms of producing more accurate estimates of the demographic parameters. The table containing all values is given in Appendix B (Table B.11a-d).

The estimates of the demographic parameters obtained by means of the EM algorithm always gave a lower percentage bias than those computed by means of the ELEFAN I method, as shown by the positive values of the percentage variation reported in Table 4.34.

Table 4.33 Medians of the estimates of the demographic parameters computed by means of the ELEFAN I method and the EM algorithm with the Red mullet length data. Refer to Table 3.1 for the input data used in the generation of the Red mullet hypothetical population.

	Estimates	
Demographic parameters	ELEFAN I method	EM algorithm
L_∞ *(cm)*	20.55	20.85
k $(year^{-1})$	0.23	0.38
t_0 *(year)*	-1.85	-1.21
mean 1 (cm)	7.56	7.62
mean 2 (cm)	11.99	12.09
mean 3 (cm)	14.78	14.98
mean 4 (cm)	15.79	16.51
mean 5 (cm)	16.25	16.54
mean 6 (cm)	16.18	16.65
mean 7 (cm)	16.81	16.84
SD 1 (cm)	0.93	0.91
SD 2 (cm)	2.03	1.22
SD 3 (cm)	0.37	1.75
SD 4 (cm)	0.32	1.64
SD 5 (cm)	0.27	2.09
SD 6 (cm)	3.61	3.52
SD 7 (cm)	0.05	0.62

Table 4.34 Medians of the percentage bias of the demographic parameters computed by means of the ELEFAN I method and the EM algorithm with the Red mullet length data. Refer to Table 3.1 for the input data used in the generation of the Red mullet hypothetical population.

% Bias			
Demographic parameters	ELEFAN I method	EM algorithm	% Variation
L_∞	-1.90	-0.48	74.51
k	-51.10	-20.17	60.52
t_0	164.64	73.11	55.60
mean 1	-0.52	0.30	43.34
mean 2	-1.08	-0.29	73.00
mean 3	-2.31	-1.06	54.26
mean 4	-8.15	-3.96	51.34
mean 5	-11.50	-9.95	13.49
mean 6	-17.28	-14.91	13.71
mean 7	-19.50	-19.39	0.56
SD 1	43.44	39.71	8.57
SD 2	-125.05	35.22	71.83
SD 3	-68.13	52.50	22.94
SD 4	-77.38	16.85	78.22
SD 5	-83.84	26.60	68.28
SD 6	-89.34	85.48	4.32
SD 7	-97.67	-71.30	27.00

The medians of the estimates and the corresponding percentage bias of the demographic parameters computed by means of the ELEFAN I method and the EM algorithm in the sub-sampling of 1000 length measurements extracted from the European hake hypothetical population are presented in Tables 4.35 and 4.36 respectively. Table 4.36 also reports the percentage contribution of the EM algorithm (% variation) in terms of producing more accurate estimates of the demographic parameters. The tables containing all values are given in Appendix B (Table B.12a-d).

The estimates of the demographic parameters obtained by means of the EM algorithm always gave a lower percentage of bias than those computed by means of the ELEFAN I method, as shown by the positive values of the percentage variation reported in Table 4.36.

Table 4.35 Medians of the estimates of the demographic parameters computed by means of the ELEFAN I method and the EM algorithm with the European hake length data. Refer to Table 3.2 for the input data used in the generation of the European hake hypothetical population.

Estimates		
Demographic parameters	ELEFAN I method	EM algorithm
L_∞ (cm)	81.90	76.49
k (year^{-1})	0.07	0.14
t_0 (year)	-4.39	-2.12
mean 1 (cm)	19.41	19.40
mean 2 (cm)	27.15	26.90
mean 3 (cm)	33.27	33.19
mean 4 (cm)	41.11	36.36
mean 5 (cm)	41.06	41.54
mean 6 (cm)	42.26	42.55
mean 7 (cm)	-	-
SD 1 (cm)	4.17	1.24
SD 2 (cm)	4.78	5.62
SD 3 (cm)	6.03	5.80
SD 4 (cm)	11.92	3.37
SD 5 (cm)	8.59	4.11
SD 6 (cm)	6.10	4.81
SD 7 (cm)	-	-

Table 4.36 Medians of the percentage bias of the demographic parameters computed by means of the ELEFAN I method and the EM algorithm with the European hake length data. Refer to Table 3.2 for the input data used in the generation of the European hake hypothetical population.

% Bias			
Demographic parameters	ELEFAN I method	EM algorithm	% Variation
L_∞	29.55	21.00	28.94
k	-53.33	-5.98	88.78
t_0	1085.65	473.87	56.35
mean 1	0.11	0.04	59.54
mean 2	-0.27	-0.14	47.95
mean 3	1.12	0.87	22.44
mean 4	-3.22	-1.35	58.24
mean 5	-12.89	-11.87	7.89
mean 6	-21.27	-20.72	2.56
mean 7	-	-	-
SD 1	189.35	-13.71	92.76
SD 2	238.20	189.59	20.41
SD 3	456.44	134.92	70.44
SD 4	329.01	20.96	93.63
SD 5	-164.31	26.46	83.90
SD 6	-65.68	30.70	53.26
SD 7	-	-	-

Table 4.37 reports the results of the Shapiro-Wilk test performed on the percentage bias datasets obtained by estimating the demographic parameters using the ELEFAN I method and the EM algorithm with the Red mullet length data. Most percentage bias distributions did not follow a normal distribution (*p*-values less than 0.05).

Table 4.38 reports the results of the Shapiro-Wilk test performed on the percentage bias datasets obtained by estimating the demographic parameters using the ELEFAN I method and the EM algorithm with the European hake length data. Most percentage bias distributions did not follow a normal distribution (*p*-values less than 0.05).

Tables 4.39 reports the results of the Mann-Whitney and the Kolmogorov-Smirnov tests performed on the percentage bias datasets obtained by estimating the demographic parameters using the ELEFAN I method and the EM algorithm with the Red mullet length data.

The medians of the percentage bias obtained by means of the EM algorithm were always found to be statistically different (*p*-values less than 0.05) to those computed by means of the ELEFAN I method. The distributions of the percentage bias obtained by means of the EM algorithm were found to be statistically different (*p*-values less than 0.05) to those computed by means of the ELEFAN I method. The exceptions were the parameter L_∞, the second, the third, the fifth and the sixth mean length-at-age, and the second standard deviation.

Tables 4.40 reports the results of the Mann-Whitney and the Kolmogorov-Smirnov tests performed on the percentage bias datasets obtained by estimating the demographic parameters using the ELEFAN I method and the EM algorithm with the European hake length data.

The medians of the percentage bias obtained by means of the EM algorithm were found to be statistically different (*p*-values less than 0.05) to those computed by means of the ELEFAN I method, except for the sixth mean length-at-age. The distributions of the percentage bias obtained by means of the EM algorithm were found to be statistically different (*p*-values less than 0.05) to those computed by means of the ELEFAN I method, except for the parameter L_∞ and the first, the third, the fifth and the sixth mean length-at-age.

Table 4.37 Results of the Shapiro-Wilk test performed on the percentage bias datasets obtained by estimating the demographic parameters using the ELEFAN I method and the EM algorithm with the Red mullet length data.

Demographic parameters	ELEFAN I method		EM algorithm	
	W	p(normal)	W	p(normal)
L_∞	0.9827	2.160E-01	0.9549	1.777E-03
k	0.8634	3.816E-08	0.9717	2.980E-02
t_0	0.9443	3.571E-04	0.8799	1.790E-07
mean 1	0.9855	3.475E-01	0.8523	1.449E-08
mean 2	0.5933	3.222E-15	0.9154	8.069E-06
mean 3	0.5444	4.250E-16	0.9400	2.269E-04
mean 4	0.4603	4.457E-14	0.9190	4.508E-04
mean 5	0.9918	9.993E-01	0.9778	8.783E-01
mean 6	0.9313	6.053E-01	0.9389	6.473E-01
mean 7	N = 1		N = 1	
SD 1	0.9754	5.787E-02	0.8282	2.013E-09
SD 2	0.9583	3.069E-03	0.9568	2.380E-03
SD 3	0.9646	1.017E-02	0.9358	1.274E-04
SD 4	0.9621	4.671E-02	0.8543	2.224E-06
SD 5	0.9589	4.677E-01	0.6907	1.494E-05
SD 6	0.9057	4.423E-01	0.9913	9.639E-01
SD 7	N = 1		N = 1	

Table 4.38 Results of the Shapiro-Wilk test performed on the percentage bias datasets obtained by estimating the demographic parameters using the ELEFAN I method and the EM algorithm with the European hake length data.

Demographic parameters	ELEFAN I method		EM algorithm	
	W	p(normal)	W	p(normal)
L_∞	0.9512	9.934E-04	0.9240	2.320E-05
k	0.8398	5.056E-09	9.1220	5.540E-06
t_0	0.9764	6.976E-02	0.9715	2.861E-02
mean 1	0.9882	5.236E-01	0.7515	1.027E-11
mean 2	0.9818	1.840E-01	0.8273	1.866E-09
mean 3	0.7882	3.025E-10	0.9520	1.683E-03
mean 4	0.9525	1.051E-02	0.9481	1.839E-03
mean 5	0.9292	2.367E-02	0.9309	4.404E-03
mean 6	0.7957	3.712E-02	0.8044	4.185E-03
mean 7	-	-	-	-
SD 1	0.7640	2.232E-11	0.5923	3.085E-15
SD 2	0.9899	6.549E-01	0.8672	5.423E-08
SD 3	0.9829	2.662E-01	0.9461	7.143E-04
SD 4	0.9814	3.930E-01	0.9399	6.315E-04
SD 5	0.9574	1.780E-01	0.8963	1.850E-04
SD 6	0.7839	2.831E-02	0.8122	5.294E-03
SD 7	-	-	-	-

Table 4.39 Results of the Mann-Whitney and the Kolmogorov-Smirnov tests performed on the percentage bias datasets obtained by estimating the demographic parameters using the ELEFAN I method and the EM algorithm with the Red mullet length data.

Demographic parameters	Mann-Whitney		Kolmogorv-Smirnov	
	T	p(same)	D	p(same)
L_∞	4478.0	2.026E-02	0.14	2.6055E-01
k	1.8	6.792E-15	0.67	1.1244E-20
t_0	3075.0	2.572E-06	0.46	5.6969E-10
mean 1	3480.0	2.050E-04	0.31	9.2450E-05
mean 2	4961.0	9.251E-02	0.16	1.3998E-01
mean 3	4121.0	4.331E-02	0.15	2.0637E-01
mean 4	1446.0	2.822E-03	0.33	1.1881E-03
mean 5	172.0	1.028E-02	0.32	1.7460E-01
mean 6	9.0	9.025E-02	0.35	8.7778E-01
mean 7	N = 1		N = 1	
SD 1	4350.0	1.122E-02	0.33	2.4462E-05
SD 2	380.0	1.517E-29	0.93	1.0000E+00
SD 3	503.0	4.073E-27	0.78	1.5586E-27
SD 4	126.0	5.333E-20	0.88	9.0890E-23
SD 5	22.0	2.574E-07	0.77	1.1399E-06
SD 6	0.0	1.996E-02	1.00	6.8607E-03
SD 7	N = 1		N = 1	

Table 4.40 Results of the Mann-Whitney and the Kolmogorov-Smirnov tests performed on the percentage bias datasets obtained by estimating the demographic parameters using the ELEFAN I method and the EM algorithm with the European hake length data.

Demographic parameters	Mann-Whitney		Kolmogorv-Smirnov	
	T	p(same)	D	p(same)
L_∞	3931.0	9.002E-03	0.18	6.9092E-02
k	673.0	4.047E-26	0.76	1.7587E-26
t_0	1188.0	1.243E-20	0.75	8.4401E-26
mean 1	4476.0	2.009E-02	0.18	6.9092E-02
mean 2	4900.0	8.070E-03	0.23	8.2164E-03
mean 3	4006.0	3.247E-02	0.13	4.0976E-01
mean 4	2473.0	9.503E-03	0.46	7.3261E-08
mean 5	942.0	9.234E-03	0.24	1.5838E-01
mean 6	45.0	6.217E-01	0.29	7.5581E-01
mean 7	-	-	-	-
SD 1	2139.0	2.738E-12	0.58	1.3361E-15
SD 2	4923.0	8.517E-03	0.28	5.8125E-04
SD 3	1035.0	2.006E-19	0.82	1.2406E-28
SD 4	1665.0	4.159E-06	0.65	3.9423E-15
SD 5	596.0	1.404E-03	0.67	2.3792E-09
SD 6	3.0	5.522E-03	0.86	5.7786E-04
SD 7	-	-	-	-

4.2 Real data

4.2.1 The Birgé and Rozenholc algorithm

4.2.1.1. The ELEFAN I method

Table 4.41 displays the estimates and the corresponding percentage bias of the two growth parameters (L_∞ and k) calculated by means of the ELEFAN I method using the two data partitions for grouping the 1568 Red mullet length measurements. The class number and the corresponding class width obtained using the two data partitions are also reported.

The estimates of the two growth parameters (L_∞ and k) obtained using the Birgé and Rozenholc algorithm gave a lower percentage bias than those obtained with the classical *1 cm* interval width. Moreover, the class number obtained by grouping the data using the Birgé and Rozenholc algorithm was higher (i.e. a narrower class width) than that obtained with the classical *1 cm* interval width.

Table 4.41 Estimates and corresponding percentage bias of the two growth parameters (L_∞ and k) calculated by means of the ELEFAN I method using the two data partitions for grouping the 1568 Red mullet length measurements. The class number and the corresponding class width are also reported. Refer to Table 3.1 for the true values of the Red mullet demographic parameters.

Data partition	Estimates		% Bias		Class number	Class width (cm)
	L_∞ *(cm)*	k *(year^{-1})*	L_∞	k		
Birgé and Rozenholc algorithm	20.60	0.30	-1.67	-36.17	36	0.54
1 cm	19.00	0.20	-9.31	-57.45	19	1.00

Table 4.42 displays the estimates and the corresponding percentage bias of the two growth parameters (L_∞ and k) calculated by means of the ELEFAN I method using the two data partitions for grouping the 2136 European hake length measurements. The class number and the corresponding class width obtained using the two data partitions are also reported.

The estimates of the two growth parameters (L_∞ and k) obtained using the Birgé and Rozenholc algorithm gave a lower percentage bias than those obtained with the classical *2 cm* interval width. Moreover, the class number obtained by grouping the data using the Birgé and Rozenholc algorithm was higher (i.e. a narrower class width) than that obtained with the classical *2 cm* interval width.

Table 4.42 Estimates and corresponding percentage bias of the two growth parameters (L_∞ and k) calculated by means of the ELEFAN I method using the two data partitions for grouping the 2136 European hake length measurements. The class number and the corresponding class width are also reported. Refer to Table 3.2 for the true values of the European hake demographic parameters.

Data partition	Estimates		% Bias		Class number	Class width (cm)
	L_∞ (cm)	k (year^{-1})	L_∞	k		
Birgé and Rozenholc algorithm	67.70	0.11	7.09	-26.67	42	1.39
2 cm	71.70	0.08	13.41	-46.67	30	2.00

4.2.1.2. The Bhattacharya method

Table 4.43 displays the estimates and the corresponding percentage bias of the mean lengths-at-age and the standard deviations calculated by means of the Bhattacharya method using the two data partitions for grouping the 1568 Red mullet length measurements.

The estimates of the mean lengths-at-age and the standard deviations obtained using the Birgé and Rozenholc algorithm gave a lower percentage bias than those obtained with the classical *1 cm* interval width. Nevertheless, the use of the classical *1 cm* interval width resulted in the identification of all seven cohorts present in the Red mullet population.

Table 4.44 displays the estimates and the corresponding percentage bias of the mean lengths-at-age and the standard deviations calculated by means of the Bhattacharya method using the two data partitions for grouping the 2136 European hake length measurements.

The estimates of the mean lengths-at-age and the standard deviations obtained using the Birgé and Rozenholc algorithm gave a lower percentage bias than those obtained with the classical *2 cm* interval width. Nevertheless, the use of the classical *2 cm* interval width resulted in the identification of all seven cohorts present in the European hake population.

Table 4.43 Estimates and corresponding percentage bias of the mean lengths-at-age and the standard deviations calculated by means of the Bhattacharya method using the two data partitions for grouping the 1568 Red mullet length measurements. Refer to Table 3.1 for the true values of the Red mullet demographic parameters.

Parameters	Estimates		% Bias	
	Birgé and Rozenholc algorithm	1 cm	Birgé and Rozenholc algorithm	1 cm
mean 1 (cm)	7.29	6.24	-4.13	-17.87
mean 2 (cm)	11.50	6.95	-5.10	-42.62
mean 3 (cm)	15.26	7.38	0.82	-51.23
mean 4 (cm)	17.25	8.01	0.36	-53.44
mean 5 (cm)	18.89	8.72	2.88	-52.51
mean 6 (cm)	-	10.52	-	-46.23
mean 7 (cm)	-	11.42	-	-45.34
SD 1 (cm)	0.65	0.16	0.14	-74.79
SD 2 (cm)	0.81	0.25	-9.98	-72.14
SD 3 (cm)	1.26	0.26	9.78	-77.11
SD 4 (cm)	0.95	0.37	-32.31	-73.40
SD 5 (cm)	1.21	0.21	-26.65	-87.50
SD 6 (cm)	-	0.18	-	-90.58
SD 7 (cm)	-	0.22	-	-89.75

Table 4.44 Estimates and corresponding percentage bias of the mean lengths-at-age and the standard deviations calculated by means of the Bhattacharya method using the two data partitions for grouping the 2136 European hake length measurements. Refer to Table 3.2 for the true values of the European hake demographic parameters.

Parameters	Estimates		% Bias	
	Birgé and Rozenholc algorithm	2 cm	Birgé and Rozenholc algorithm	2 cm
mean 1 (cm)	18.93	18.71	-2.39	-3.49
mean 2 (cm)	26.97	28.65	-0.40	5.80
mean 3 (cm)	32.56	35.26	-1.02	7.18
mean 4 (cm)	39.20	39.14	-1.69	-1.87
mean 5 (cm)	48.61	63.75	3.12	35.24
mean 6 (cm)	-	58.04	-	8.14
mean 7 (cm)	-	63.57	-	2.54
SD 1 (cm)	1.49	1.49	3.24	3.62
SD 2 (cm)	2.45	2.88	26.53	48.60
SD 3 (cm)	3.08	4.01	32.80	72.80
SD 4 (cm)	1.69	5.35	-39.23	92.45
SD 5 (cm)	1.85	1.53	-43.16	-52.90
SD 6 (cm)	-	2.20	-	-40.10
SD 7 (cm)	-	1.11	-	-73.80

4.2.2 The Expectation-Maximization algorithm

The estimates and the corresponding percentage bias of the demographic parameters computed by means of the ELEFAN I method and the EM algorithm with the 1568 Red mullet length measurements are presented in Tables 4.45 and 4.46 respectively. Table 4.46 also reports the percentage contribution of the EM algorithm (% variation) in terms of producing more accurate estimates of the demographic parameters.

The estimates of the demographic parameters obtained by means of the EM algorithm gave a lower percentage bias than those computed by means of the ELEFAN I method, as shown by the positive values of the percentage variation reported in Table 4.46.

Table 4.45 Estimates of the demographic parameters computed by means of the ELEFAN I method and the EM algorithm with the 1568 Red mullet length measurements. Refer to Table 3.1 for the true values of the Red mullet demographic parameters.

	Estimates	
Demographic parameters	ELEFAN I method	EM algorithm
L_∞ *(cm)*	21.30	21.10
k *(year^{-1})*	0.64	0.61
t_0 *(year)*	-1.10	-1.09
mean 1 (cm)	7.81	7.68
mean 2 (cm)	12.33	12.24
mean 3 (cm)	15.76	15.48
mean 4 (cm)	-	-
mean 5 (cm)	-	-
mean 6 (cm)	-	-
mean 7 (cm)	-	-
SD 1 (cm)	1.23	0.72
SD 2 (cm)	2.40	0.97
SD 3 (cm)	3.19	1.55
SD 4 (cm)	-	-
SD 5 (cm)	-	-
SD 6 (cm)	-	-
SD 7 (cm)	-	-

Table 4.46 Percentage bias of the demographic parameters computed by means of the ELEFAN I method and the EM algorithm with the 1568 Red mullet length measurements. Refer to Table 3.1 for the true values of the Red mullet demographic parameters.

% Bias			
Demographic parameters	ELEFAN I method	EM algorithm	% Variation
L_{∞}	1.67	0.72	57.14
k	36.17	29.79	17.65
t_0	56.57	55.71	1.52
mean 1	2.76	1.05	61.90
mean 2	1.72	0.98	43.11
mean 3	4.13	2.28	44.82
mean 4	-	-	-
mean 5	-	-	-
mean 6	-	-	-
mean 7	-	-	-
SD 1	89.03	10.87	87.80
SD 2	166.51	7.83	95.30
SD 3	177.30	34.80	80.37
SD 4	-	-	-
SD 5	-	-	-
SD 6	-	-	-
SD 7	-	-	-

The estimates and the corresponding percentage bias of the demographic parameters computed by means of the ELEFAN I method and the EM algorithm with the 2136 European hake length measurements are presented in Table 4.47. and 4.48 respectively. Table 4.48 also reports the percentage contribution of the EM algorithm (% variation) in terms of producing more accurate estimates of the demographic parameters.

The estimates of the demographic parameters obtained by means of the EM algorithm gave a lower percentage bias than those computed by means of the ELEFAN I method, as shown by the positive values of the percentage variation reported in Table 4.48.

Table 4.47 Estimates of the demographic parameters computed by means of the ELEFAN I method and the EM algorithm with the 2136 European hake length measurements. Refer to Table 3.2 for the true values of the European hake demographic parameters.

Estimates		
Demographic parameters	ELEFAN I method	EM algorithm
L_∞ *(cm)*	67.70	64.99
k (year^{-1})	0.19	0.19
t_0 *(year)*	-5.01	-0.70
mean 1 (cm)	24.22	19.64
mean 2 (cm)	27.97	27.84
mean 3 (cm)	34.66	33.67
mean 4 (cm)	45.62	44.85
mean 5 (cm)	-	-
mean 6 (cm)	-	-
mean 7 (cm)	-	-
SD 1 (cm)	9.50	9.38
SD 2 (cm)	14.39	14.16
SD 3 (cm)	15.77	12.33
SD 4 (cm)	12.02	8.16
SD 5 (cm)	-	-
SD 6 (cm)	-	-
SD 7 (cm)	-	-

Table 4.48 Percentage bias of the demographic parameters computed by means of the ELEFAN I method and the EM algorithm with the 2136 European hake length measurements. Refer to Table 3.2 for the true values of the European hake demographic parameters.

% Bias			
Demographic parameters	ELEFAN I method	EM algorithm	% Variation
L_∞	7.09	2.80	60.49
k	26.67	21.57	19.12
t_0	1254.05	89.19	92.89
mean 1	24.91	1.29	94.82
mean 2	3.29	2.81	14.61
mean 3	5.35	2.34	56.25
mean 4	14.39	12.46	13.41
mean 5	-	-	-
mean 6	-	-	-
mean 7	-	-	-
SD 1	559.72	551.39	1.49
SD 2	641.75	629.90	1.85
SD 3	579.74	431.47	25.58
SD 4	332.37	193.53	41.77
SD 5	-	-	-
SD 6	-	-	-
SD 7	-	-	-

5. DISCUSSION

5.1 The Birgé and Rozenholc algorithm

The trials conducted show that the Birgé and Rozenholc algorithm was efficient for both techniques chosen to represent length-frequency analysis (i.e. the ELEFAN I method, a non-parametric approach, and the Bhattacharya method, a parametric approach) and for the two marine species chosen as representatives of opposing life-histories (the Red mullet, a fast-growing species, and the European hake, a slow-growing species). Moreover, the results obtained were very encouraging with both simulated and real data.

In this regard, it must be noted that the simulated length-frequency distributions can be considered to be high-quality samples of the hypothetical populations in terms of lack of bias, sample size and frequency of sampling. In other words, real life length-frequency data is seldom of this quality (Castro and Erzini, 1988).

Considering first the experiments carried out with the simulated data, the estimates of the two growth parameters (L_∞ and k) obtained by means of the ELEFAN I method on the histograms constructed using the Birgé and Rozenholc algorithm were found to be statistically better (i.e. there was a less percentage bias) than those obtained with the classical interval widths (*1 cm* for the Red mullet and *2 cm* for the European hake), with only a few exceptions (Tables 4.1 and 4.3).

The Mann-Whitney test (Table 4.7) showed no statistical difference between the median values of the percentage bias of the two growth parameters (L_∞ and k) in the sub-sampling of 500 Red mullet length measurements. This may be due to the fact that, as reported in Table 4.2, the value of the interval width calculated using the Birgé and Rozenholc algorithm was very close to the *1 cm* interval width (i.e. 0.75 cm) commonly used in the fisheries studies for grouping Red mullet length data.

No statistical difference occurred either for L_∞ and k in the sub-samplings of 500 and 200 European hake length measurements (Table 4.9). This can be explained for the sub-sampling of 500 length measurements due to the close proximity of the value of the interval width calculated using the Birgé and Rozenholc algorithm to the classical *2 cm* interval width (i.e. 2.52 cm) (Table 4.4). A similar hypothesis cannot be assumed, however, for the subsampling of 200 length measurements, where the value of the interval width calculated using the Birgé and Rozenholc algorithm was equal to 5.33 cm. Nevertheless, as reported by Isaac (1990), the ELEFAN I method seems to be more adequate for populations of small fishes with faster growth rates and a shorter life span. Thus, in this case, since the European hake is a typical slow-growing species, the ELEFAN I method could have influenced the performance of the Birgé and Rozenholc algorithm in the sub-sampling of 200 measurements.

The same assumption could be made for the k estimate in the sub-sampling of 100 European hake length measurements (Table 4.3). In fact, the median value of the percentage bias obtained by means of the ELEFAN I method on the histograms constructed using the Birgé and Rozenholc algorithm was higher (-93,33%) than that obtained with the classical *2 cm* interval width (-60.00%).

Thus, considering the results obtained using the Birgé and Rozenholc algorithm in the four samples in terms of precision of the estimated parameters, it does not seem possible to find a specific rule to predict the performance of the algorithm with an increment of the sample size. In the case of the Red mullet, as shown in Figure 4.1A, the median value of the percentage bias for L_∞ decreased with an increment of the sample size, with the opposite trend occurring for k. Otherwise, for the European hake, as shown in Figure 4.2A, the median value of the percentage bias for L_∞ increased up to the sub-sampling of 500 length measurement, with the value decreasing in the sub-sampling of 1000 length measurements. The median value, however, remained higher than the values obtained in the sub-samplings of 100 and 200 length measurements. The median value of the percentage bias for k decreased up to the sub-sampling of 500 length measurements and then increased in the sub-sampling of 1000 length measurements, becoming higher than the value obtained in the sub-sampling of 200 length measurements.

As regards the sign (negative or positive) of the median value of the percentage bias reported in Tables 4.1 and 4.3, it appears that the *k* parameter was always underestimated for all data partitions and for both the species considered, with the only exception being the sub-sampling of 100 Red mullet length measurements grouped using the Birgé and Rozenholc algorithm. This result is in agreement with Isaac (1990), who reported that the use of the ELEFAN I method leads to an underestimation of the *k* parameter.

Considering L_∞ on the other hand, this parameter was always underestimated in the case of the Red mullet (Tables 4.1) and always overestimated in the case of the European hake (Tables 4.3), with the only exception being the sub-sampling of 100 European hake length measurements grouped using the Birgé and Rozenholc algorithm. These data partially agree with Isaac (1990), who reported that the use of the ELEFAN I method leads to an overestimation of L_∞.

As previously mentioned, the efficiency of the Birgé and Rozenholc algorithm was also evident in the experiments conducted using the Bhattacharya method for length-frequency analysis. The estimates of the mean lengths-at-age and the standard deviations obtained with the histograms constructed using the Birgé and Rozenholc algorithm were mostly better (i.e. there was a less percentage bias) than those obtained with the classical interval widths, with only some exceptions.

The Birgé and Rozenholc algorithm was found to be efficient in the analysis of the Red mullet length data in terms of precision of the parameters estimated (Tables 4.11, 4.12, 4.13 and 4.14). All parameters were estimated better than those obtained with the classical *1 cm* interval width, with the only exceptions being the first mean length-at age in the sub-samplings of 100 and 200 length measurements and the first and second standard deviation in the sub-sampling of 100 length measurements. The Mann-Whitney test (Tables 4.25 and 4.27) showed that the differences between the median values of the percentage bias of the estimated parameters were statistically significant.

On the other hand, the Birgé and Rozenholc algorithm was less efficient in the analysis of the European hake length data, especially in the smallest sized samples (Tables 4.15, 4.16, 4.17 and 4.18). In fact, the mean lengths-at age and the standard deviations were estimated better than those obtained with the classical *2 cm* interval width only in the sub-sampling of 1000 length measurements, with the differences shown to be statistically significant by the Mann-Whitney test (Tables 4.29 and 4.31). In the sub-sampling of 500 length measurements all the mean lengths-at age and the standard deviations were estimated better, with the exception of the mean length-at age and the standard deviation of the first cohort. In the sub-sampling of 200 length measurements only the fourth and fifth mean length-at age and the third, fourth and fifth standard deviation were estimated better when the histograms were constructed using the Birgé and Rozenholc algorithm. Finally, in the sub-sampling of 100 length measurements, no values of mean length-at age and standard deviation were estimated better than those obtained with the classical *2 cm* interval width. This may be due to the fact that, as reported in Table 4.4, the median value of the interval width obtained using the Birgé and Rozenholc algorithm was extremely high, being equal to 16.16 cm. A similar hypothesis could be assumed even for the sub-sampling of 200 length measurements, where the median value of the interval width was equal to 5.33 cm.

When considering the performance of the Birgé and Rozenholc algorithm with an increment of the sample size, there was an evident decrease of the median value of percentage bias with an increase of the sample size for both the mean lengths-at age (Tables 4.13 and 4.17) and the standard deviations (Tables 4.14 and 4.18). This decrease was less evident in the case of the classical data partition for both the European hake estimated parameters and for the Red mullet estimated standard deviations. There was, instead, an increase in the median value of the percentage bias for the mean lengths-at age in the case of the classical *1 cm* Red mullet interval width.

As regards the number of cohorts identified with the Bhattacharya method, both the median and the maximum number of cohorts increased with the increase of the sample size for both the data partitions (Tables 4.15 and 4.20). These results are similar to those reported by Erzini (1990). Nevertheless, the median and maximum number of identified cohorts obtained by grouping the length data with the classical partitions were always higher than those obtained with the partition constructed using the Birgé and Rozenholc algorithm.

In the case of the Red mullet (Table 4.15), the Birgé and Rozenholc algorithm consented to identify all the seven cohorts present in the population only in the sub-samplings of 500 and 1000 length measurements, while all the cohorts were just identified in the sub-sampling of 200 length measurements grouped with the classical *1 cm* interval width. Nevertheless, the use of the classical *1 cm* interval width resulted in an overestimation of the number of identified cohorts, as shown both by the median number of identified cohorts in the sub-samplings of 500 and 1000 length measurements and by the maximum number of identified cohorts in the sub-samplings of 200, 500 and 1000 length measurements. On the other hand, the use of the Birgé and Rozenholc algorithm resulted in an overestimation of the number of identified cohorts only in four cases in the sub-sampling of 1000 length measurements.

On the other hand, for the European hake (Table 4.20), the median and the maximum number of identified cohorts obtained by means of the Bhattacharya method on the histograms constructed using the Birgé and Rozenholc algorithm were always lower than those obtained with the classical *2 cm* interval width. The use of the Birgé and Rozenholc algorithm never resulted in the identification of all the seven cohorts present in the population; moreover, the number (median and maximum) of identified cohorts was particularly low in the sub-sampling of 100 length measurements and, only with reference to the median number, in the sub-sampling of 200 length measurements. Finally, the two data partitions never resulted in an overestimation of the number of identified cohorts.

Considering the values of the interval width calculated by the Birgé and Rozenholc algorithm in the four samples, it is evident that the output of the algorithm depends on the sample size. In the case of the Red mullet (Table 4.2), the median value of the interval width was higher (i.e. a lower class number) than that obtained with the classical *1 cm* interval width in the sub-samplings of 100 (2.20 cm) and 200 (1.30 cm) length measurements; the opposite situation (a higher class number and a narrower class width) occurred in the sub-samplings of 500 (interval width equal to 0.75 cm) and 1000 (interval width equal to 0.59 cm) length measurements. Otherwise, for the European hake (Table 4.2), the median value of the interval width was higher than that obtained with the classical *2 cm* interval width in the sub-samplings of 100 (16.16 cm), 200 (5.33 cm) and 500 (2.52 cm) length measurements; the opposite situation occurred in the sub-sampling of 1000 (interval width equal to 1.79 cm) length measurements.

The efficiency of the Birgé and Rozenholc algorithm was even more evident in the experiments carried out with real length data as discussed below.

The estimates of the two growth parameters (L_∞ and k) obtained by means of the ELEFAN I method on the histograms constructed with the Birgé and Rozenholc algorithm were always better (i.e. there was a less percentage bias) than those obtained with the classical interval widths (Tables 4.41 and 4.42). According to Isaac (1990), the growth parameter k was always underestimated both for the Red mullet (Table 4.41) and the European hake (Table 4.42). Considering instead what occurred for L_∞, the parameter was underestimated in the case of the Red mullet and overestimated in the case of the European hake.

As regards the results of the experiments conducted with the Bhattacharya method, the estimates of the mean lengths-at-age and the standard deviations obtained with the histograms constructed using the Birgé and Rozenholc algorithm were always better (i.e. there was a less percentage bias) than those obtained with the classical interval widths (Tables 4.43 and 4.44). The number of identified cohorts obtained by grouping the length data with the classical partitions was always higher than that obtained with the partition constructed using the Birgé and Rozenholc algorithm. The algorithm consented the identification of only five of the seven cohorts present in the populations of the two species considered. On the other hand, the use of the classical interval widths resulted in the identification of all seven cohorts. Nevertheless, in the case of the Red mullet, the use of the classical *1 cm* interval width resulted in an overestimation of the number of cohorts, as revealed also by the high values of the percentage bias of the seven mean lengths-at age and standard deviations shown in Table 4.43. A similar overestimation did not occur in the case of the European hake (Table 4.44).

Finally, considering the value of the interval width calculated by the Birgé and Rozenholc algorithm, it was always found to be less than the classical interval widths and was equal to 0.54 cm for the Red mullet (Table 4.41) and 1.39 cm for the European hake (Table 4.42).

Moreover, as discussed previously, the Birgé and Rozenholc algorithm proved to be an efficient method for selecting the number of intervals to be used for building a regular histogram. This seems to be of great interest since in fisheries research length-frequency distributions are commonly analyzed by means of histograms.

The histogram, a statistical procedure that shows the distribution of a variable such as length, may be defined as a data smoother, with the interval width being the smoother parameter (Härdle, 1991). Here, the number of modes depends on the interval width. In this sense, in fisheries research a fundamental question must be "What is the best interval width?"

It is possible to quote several suggestions from literature. An interval size of 1 cm for small species (< 30 cm) and 2 cm for larger species are commonly used. Caddy (1986) examined a number of Length-Frequency Analysis studies and found that the interval width should be small enough to allow successive peaks to be separated by five or six size class intervals. Wolff (1989) proposed an empirically derived formula for the selection of the optimum interval size, based on the maximum observed size and the estimated number of age classes in a sample. In his study, Erzini (1990) argues that the optimum interval size for grouping length data is a function of sample size and biological characteristics such as length-at-age variability, recruitment pattern, growth rate and maximum size. These factors affect the definition of the modes in the distribution. Erzini's paper supports Caddy's suggestion that empirically based methods for determining the interval width may only be useful to provide rough estimates.

However, the research conducted into fisheries studies so far has only come up with some empirical rules of thumb and evaluations on the effects of the representativity of the sample, the sample size and the selection of class interval on the results of length-based methods (MacDonald and Pitcher, 1979; Schnute and

Fournier, 1980; Pauly *et al.*, 1984; Caddy, 1986; Hoenig *et al.*, 1987; Castro and Erzini, 1988; Wolff, 1989; Erzini, 1990; Isaac, 1990; Scott, 1992; King, 1995; Mytilineou and Sardá, 1995). Only a limited number of fisheries studies have been conducted to evaluate the efficiency of more sophisticated rules for determining the optimal number of classes from the available data. In a recent study carried out by Sanvicente-Añorve *et al.* (2003) to examine length-frequency distributions of Butterfish larvae, the optimal bandwidth chosen was based on the Silverman (1986) rule. A similar approach was used in other fisheries research (Salgado-Ugarte *et al.*, 1993, 1995a, 1995b, 1997, 2000, 2002).

In general, the statistical methods that have been developed to solve the problem of choosing the number of bins of a partition are based on a number of asymptotic considerations (Sturges, 1926; Akaike, 1974; Tarter and Kronmal, 1976; Tukey, 1977; Silverman, 1978; Scott, 1979; Freedman and Diaconis, 1981; Silverman, 1981a; Rudemo, 1982; Hoaglin, 1983; Devroye and Györfi, 1985; Scott, 1985; Silverman, 1986; Rissanen, 1987; Taylor, 1987; Daly, 1988; Hall and Hannan, 1988; Fox, 1990; Hall, 1990; Scott, 1992; Kanazawa, 1993; He and Meeden, 1997; Wand, 1997).

The problem with these methods is that they do not perform well in the case of small sample sizes due to their asymptotic nature. Moreover, many of these methods assume some prior information about the shape of the density of the data (Birgé and Rozenholc, 2002). On the other hand, the approach recently proposed by Birgé and Rozenholc (2002) is a typical example of model selection methods that make a compromise between the complexity of the model and its fidelity to the data.

5.2 The Expectation-Maximization algorithm

During the present study, the efficiency of the algorithm was evident for the two marine species chosen as representatives of opposing life-histories (the Red mullet and the European hake) both with simulated and real length data.

Considering first the experiments carried out using the simulated data, the estimates of the demographic parameters obtained by means of the EM algorithm were always better (i.e. there was a less percentage bias) than those computed by means of the ELEFAN I method (Tables 4.33 and 4.35). The values of the percentage contribution of the EM algorithm in terms of producing more accurate estimates of the demographic parameters were always positive (Tables 4.34 and 4.36). In addition, as reported in Tables 4.39 and 4.40, the Mann-Whitney test showed that the differences between the median values of the percentage bias of the estimated parameters obtained with the two approaches were always statistically significant.

As regards the sign (negative or positive) of the median value of the percentage bias reported for the Red mullet in Table 4.34, the use of the EM algorithm changed negative values to positive values for the following seven parameters: the first mean length-at age, the first, the second, the third, the fourth, the fifth and the sixth standard deviation. The significance of this is that the ELEFAN I method gave an underestimate of these parameters while the EM algorithm overestimated them. On the other hand, for the European hake (Table 4.36), the sign of the median value of the percentage bias changed for only three parameters when using the EM algorithm: from positive to negative for the first standard deviation and from negative to positive for the fifth and sixth standard deviation.

In the case of the Red mullet (Table 4.33), the maximum number of identified cohorts was equal to seven; on the other hand, for the European hake (Table 4.35), the maximum number of identified cohorts was equal to six.

As previously mentioned, the efficiency of the EM algorithm became also evident in the experiments carried out with real length data for both species considered. The estimates of the demographic parameters obtained by means of the EM algorithm were always better (i.e. there was a less percentage bias) than those computed by means of the ELEFAN I method (Tables 4.45 and 4.47). The values of the percentage contribution of the EM algorithm were always positive (Tables 4.46 and 4.8).

As regards the sign (negative or positive) of the median percentage bias, the use of the EM algorithm did not determine a change in the value both for the Red mullet (Table 4.46) and for the European hake (Table 4.48).

The Expectation-Maximization (EM) algorithm has become a convenient procedure for obtaining maximum likelihood estimates for incomplete (e.g. grouped, censored or truncated) data (Hartley, 1958; Dempster *et al.*, 1977; Wu, 1983; Redner and Walker, 1984; Tanner, 1996; Little and Rubin, 1987; McLachlan and Krishnan, 1997; McLachlan and Peel, 1997; McLachlan and Basford, 1988; Minka, 1998; Neal and Hinton, 1998). The EM algorithm works by the conceptual adjoining of "missing data" onto the observed data to form the "complete data" for which maximum likelihood estimation is simple. In the case of mixtures of distributions, the "missing data" is an extra variable assigning each observation to a class (Murray and Hunt, 1999).

The EM process is remarkable in part because of the simplicity and generality of the associated theory and in part because of the wide range of examples which fall under its umbrella (Dempster *et al.*, 1977). Moreover, as reported by Francis (1988), a merit of the EM algorithm is that it allows the use of any growth curve (Beverton and Holt, 1957; Pitcher and MacDonald, 1973; Cloern and Nichols, 1978; Ricker, 1979; Weatherley and Gill, 1987; Prein *et al.*, 1993; Elliott, 1994) and any functional form for the growth variability (Krause *et al.*, 1967; Cohen and Fishman, 1980; Sainsbury, 1980; McCaughran, 1981; Schnute, 1981; Bartoo and Parker, 1983).

The estimation problem for finite mixtures of normal distributions has quite a lengthy history. Karl Pearson proposed a solution in the case of a mixture of two univariate distributions with unequal variances using the method of moments (Pearson, 1894). This involved the solution of a ninth degree polynomial equation. Further investigation showed that likelihood estimation was more efficient than the method of moments for this problems (Tan and Chan, 1972).

The maximum likelihood estimation for the parameters in mixture distributions was suggested by Rao (1948), who used Fisher's method of scoring for the estimation of parameters in a mixture of two univariate normal distributions with equal variances. This appeared to be the first time the likelihood estimation was used for mixtures (Everitt and Hand, 1981). However, Butler (1986) notes that there was an investigation by Newcomb (1886) of the maximum likelihood estimation of parameters in a mixture of *K* univariate normal populations having known variances. Newcomb's investigation could be interpreted as an application of the EM algorithm (Dempster *et al.*, 1977). Butler also found that Jeffreys (1932) had essentially used the EM algorithm to compute means in two univariate normal populations, which had known variances and which were mixed in unknown proportions.

With the advent of high-speed computers, interest increased in the likelihood estimation of the parameters of mixture distributions. Hasselblad (1966, 1969) applied maximum likelihood estimation for the parameters of a mixture of *K* univariate normal distributions with equal variances, and then for mixtures of distributions from the exponential family. Day (1969) estimated the components of a mixture of two multivariate normal distributions with equal covariances. Wolfe (1967, 1970) used maximum likelihood estimation for the parameters of a mixture of *K* multivariate normal distributions with unequal covariances, and also a mixture of Bernoulli distributions. These three researchers all presented their solutions in iterative forms that could be viewed as applications of the EM algorithm.

Although the EM algorithm has been successfully applied to solve a variety of problems (Chen *et al.*, 1984; Espeland and Odoroff, 1985; Hoenig and Heisey, 1987; Millar, 1987; Wilson, 1989; Lawrence and Reilly, 1990; Silverman *et al.*, 1990; Weir, 1990; Foote, 1991; Cardon and Stormo, 1992; Fickett and Guigo, 1993; Long *et al.*, 1995; Wang *et al.*, 1996; Glazko *et al.*, 1998; Stepnowski, 1998; Hedgepeth *et al.*, 1999; Moszynnski and Hedgepeth, 2000; Hedgepeth *et al.*, 2000; Sergeev and Agapova, 2002; Kalinowski, 2004), there have been limited research studies that have been conducted to test the possible utilization of this approach for estimating parameters of the von Bertalanffy growth equation.

Of these, MacDonald and Pitcher (1979) developed a maximum likelihood method for estimating age-group parameters from fish length-frequency data, subsequently embodied in the MIX computer program (MacDonald, 1980, 1987; MacDonald and Green, 1988). Francis (1988) described a maximum likelihood approach for the analysis of growth increment data derived from tagging experiments. The EM algorithm of Dempster *et al.* (1977) was used to fit finite mixtures in the program *Multimix*, designed to cluster multivariate data with categorical and continuous variables and possibly containing missing values (Little and Schluchter, 1985; Little and Rubin, 1987; Murray and Hunt, 1999). Finally, Du (2002) developed a package called *Rmix* for the *R* statistical computing environmental to fit finite mixture distributions, with the functionality of MacDonald's MIX software, but with updated and substantially improved numerical methods based on a combination of the EM algorithm and a Newton-type method.

All the above-mentioned methods assume that the fish length data are grouped in the form of numbers of observations over successive intervals. When data are grouped, it is assumed that the midpoint of each class can represent the original measurements that fell within the class boundaries without significantly affecting subsequent analysis and identification of modes. By not making a distinction between measurements falling under the same interval information may be lost (Guiasu, 1986; Erzini, 1990).

In the present study, the EM algorithm was adapted for the first time to estimate directly the three parameters (L_∞, k and t_0) of the von Bertalanffy growth function and the parameters of a mixture distribution. In this case, the fish length data were grouped only to run the ELEFAN I method, used to obtaine the starting parameter estimates necessary for the optimization with the EM algorithm. The results obtained lead to the affirmation that the proposed EM approach for estimating fish demographic parameters could be of great interest in fisheries research and its methodological and theoretical contribution to this field could represent a landmark in the enhancement of stock assessment studies.

6. CONCLUSIONS AND FUTURE PERSPECTIVES

In the present research study, the efficiency of two algorithms was tested with the aim to contribute to the production of more accurate estimates of fish growth parameters due to the central position of the latter in the fish stock assessment process.

Concerning the Birgé and Rozenholc algorithm, this proved to be an easy and efficient method for choosing the number of bins to be used for building a regular histogram. The efficiency of the Birgé and Rozenholc algorithm was evident for both techniques chosen to represent length-frequency analysis (i.e. the ELEFAN I method, a non-parametric approach, and the Bhattacharya method, a parametric approach) and for the two marine species chosen as representatives of opposing life-histories (the Red mullet, a fast-growing species, and the European hake, a slow-growing species). Moreover, there was a trend towards a smaller optimum interval size with increasing sample size.

Nevertheless, the performance of the algorithm with small sized samples needs to be investigated further, especially in the case of slow-growing species. In this regard, a specific test could be carried out by grouping length data using the Birgé and Rozenholc algorithm and choosing, as representative of a length-frequency analysis, the Shepherd's Length-Composition Analysis (SLCA). As opposed to the ELEFAN I, the bias of the SLCA method is smaller for slow growing fishes and greater for fishes with fast growth rates (Isaac, 1990).

In addition, the results obtained using the Expectation-Maximization (EM) algorithm were very encouraging for both marine species considered, and moreover, both with simulated and real length data. The estimates of the demographic parameters obtained by means of the EM algorithm were always better (i.e. there was a less percentage bias) than those used as starting values.

Since one of the merits of the EM algorithm is that it allows the use of any functional form for the growth variability, it would be very interesting to test the efficiency of this method with the growth models recently proposed (Imsland *et al.*, 1998; Fujiwara *et al.*, 2005; Katsanevakis, 2006; Lv and Pitchford, 2007; Mullowney and James, 2007; Baldi *et al.*, in preparation).

Further perspectives also include the examination of the performance of more efficient and computationally intensive methods such as non-parametric density estimators. These approaches produce figures which are smoother than histograms, allowing the easy recognition of characteristics such as outliers, skewness and multimodality (Salgado-Ugarte *et al.*, 1993, 1995a, 1995b, 1997, 2000, 2002). One such method is the Kernel Density Estimator (KDE), first proposed by Rosenblatt (1956). Amongst its advantages are the facts that (i) it does not depend on the origin (the estimation is centred at each data point), (ii) it is continuous as it uses a smoothly changing kernel function (instead of the rectangular shape) and (iii) it can use variable bandwidths (Cox, 1966; Epanechnikov, 1969; Good and Gaskins, 1980; Silverman, 1981b, 1983; Scott, 1985; Wong, 1985; Silverman, 1986; Izenman and Sommer, 1988; Härdle, 1991; Jones, 1990; Härdle and Scott, 1992; Sanvicente-Añorve *et al.*, 2003).

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8. APPENDIX A

Pseudocode is a compact and informal high-level description of a computer programming algorithm that uses the structural conventions of programming languages, but omits detailed subroutines, variable declarations or language-specific syntax. The programming language is augmented with natural language descriptions of the details, where convenient. Pseudocode resembles, but should not be confused with, skeleton programs including dummy code, which can be compiled without errors. Flowcharts can be thought of as a graphical form of pseudocode. Textbooks and scientific publications related to computer science and numerical computation often use pseudocode in description of algorithms, so that all programmers can understand them, even if they do not all know the same programming languages. In textbooks, there is usually an accompanying introduction explaining the particular conventions in use. The level of detail of such languages may in some cases approach that of formalized general-purpose languages. A programmer who needs to implement a specific algorithm, especially an unfamiliar one, will often start with a pseudocode description, and then simply "translate" that description into the target programming language and modify it to interact correctly with the rest of the program. Programmers may also start a project by sketching out the code in pseudocode on paper before writing it in its actual language, as a top-down structuring approach.

In this work, we use the following pseudocode rules:

- Indentation (tabs) marks the structure of the block of the code;
- The interactive constructs *while*, *repeat* and *for* and the common constructs *if*, *then* and *else* have the same meaning of Turbo Pascal or C++ languages;
- The symbol “▶” indicates a comment;
- The assignment of a value to a variable (or to a constant) is indicated by the symbol “←”;
- The test of equality is indicated by the symbol “=”;
- The access to the element of the array A at the position “i” is indicated by the notation A(i).

8.1 The Birgé and Rozenholc algorithm

```
▶ NECESSARY INPUT

    Vector xdat   ▶ Original length data (fish length);

▶ DEFINING THE BIRGE' FUNCTION

m1 ← min(xdat) * .95;

m2 ← max(xdat) * 1.05;

    FOR looping variable ← 0 TO dB

        val(looping variable) ←m1+(m2 - m1) * looping variable / dB;

  END;

occB ← Compute the effective for the vector xdat through the vector val;

BirgeFunction ← sum of (vector occB * log(dB * occB / length(xdat)))-(dB – 1 + $\log(dB)^{2.5}$);

▶ COMPUTE THE BEST NUMBER OF BINS

l ← length(xdat);

ss ← (1:(5*(1+log(length(xdat))/log(2))));

yy ← compute the matrix of 2 column in which each row contains: the element of ss and the
corresponding value of BirgeFunction;

mx ← value of ss (in the matrix yy) that corresponds to the max value of BirgeFunctio;

dB ← ss(mx); ▶ THIS IS THE BEST NUMBER OF BINS

    FOR looping variable ← 0 TO dB

        val(looping variable) ←m1B+(m2 - m1) * looping variable / dB;

  END;

ampclass ← (m2 – m1)/dB;
```

8.2 The Expectation-Maximization algorithm

▶ NECESSARY INPUT

Vector *x*	▶ Preliminary estimation for each value to be optimized. It contains the value of L_∞, L, k and standard deviation for each cohort;
Matrix *Wi*	▶ Matrix of the probability density for age-composition of the population;
Vector *xdat*	▶ Original length data (fish length);
Vector *time*	▶ Age (in years) of the cohorts

▶ DECLARATION OF LOCAL VARIABLES

```
DECLARE CONSTANT INTEGER Weight ← 4;
DECLARE CONSTANT INTEGER Weight1 ← 16;
DECLARE DOUBLE MaxVerFunction;
DECLARE DOUBLE Devi;
DECLARE VECTOR Sommaperi ← a list of 0 value of the same length of vector time;
DECLARE VECTOR grdevs ← a list of 0 value of the same length of vector time;
DECLARE DOUBLE gr $L_\infty$;
DECLARE DOUBLE grL;
DECLARE DOUBLE grk;
DECLARE VECTOR pengrdevs ← a list of 0 value of the same length of vector time;
```

▶ DEFINING THE FUNCTIONS FOR COMPUTE PENALIZATIONS OF MAX LIKELIHOOD

```
SET Devi ← length of vector of means or standard deviation;
    IF first standard deviation < 0 THEN
```

```
                    COMPUTE pendev as weight1 * square value of first standard deviation;
          ENDIF
          FOR looping variable ← position of first standard deviation in the input vector
          TO length of input vector
          COMPUTE pendev as Sum of pendev and square differences of following increasing values of standard deviation
END;
```

▶ DEFINING THE FUNCTIONS FOR COMPUTE MAX LIKELIHOOD

```
     SET MaxLikFunction ← 0;
          FOR looping variable ← 1 TO length of input vector
          COMPUTE MaxLikFunction ← Sum (square of((Each Value of Wi(looping variable))*(Log(square value of each standard deviation)+(each value of xdat – $L_\infty$* (1-L*exp(-time(looping variable)*k)))) / (square value of the standard deviation defined by looping variable));
          END
COMPUTE MaxLikFunction ← MaxLikFunction + weight * pendev + (square value of (L -1) if L is >= 1);
```

▶ DEFINING THE FUNCTIONS FOR COMPUTE THE DERIVATIVE OF MAX LIKELIHOOD

```
FUNCTION ESTIMATION/MAXIMIZATION
     SET gr $L_\infty$ ← 0;
     SET grL ← 0;
     SET grk ← 0;
          FOR looping variable ← 1 TO length of vector time
```

```
        COMPUTE gr $L_\infty$ ← Sum of derivarive of Max Likelihood function with respect to $L_\infty$;

        COMPUTE grL ← Sum of derivarive of Max Likelihood function with respect to $L$;

        COMPUTE grk ← Sum of derivarive of Max Likelihood function with respect to $k$;

        COMPUTE grdevs ← Sum of derivarive of Max Likelihood function with respect to standard deviation;

    END

COMPUTE pengrdevs(1) ← -2*weight*(difference between standard deviation(2)-standard deviation(1) if standard deviation(2)<= standard deviation(1))+(2* weight1* value of standard deviation(1) if standard deviation(1)<=0);

COMPUTE pengrdevs(devi) ← 2*weight*(difference between standard deviation(devi+3)-standard deviation(devi+2) if standard deviation(devi+3)<= standard deviation(devi+2));

    FOR looping variable ← 2 TO devi-1

        COMPUTE pengrdevs(devi) ← 2*weight*((standard deviation(looping variable)-standard deviation(looping variable-1) if standard deviation(looping variable)<=standard deviation(looping variable-1))- 2*weight*((standard deviation(looping variable)-standard deviation(looping variable+1) if standard deviation(looping variable)<=standard deviation(looping variable+1));

    END

COMPUTE grL ← grL+2*((L-1) if L>=1);

COMPUTE pengrdevs ← weight*pengrdevs;

COMPUTE grdevs deviation ← grdevs +pengrdevs;

DEFINE gr as a vector ← [-gr $L_\infty$, grL, -grK, grdevs];

ENDFUNCTION
```

▶ COMPUTE THE DERIVATIVE OF MAX LIKELIHOOD FUNCTION

```
p ← series or integer from 1 to $1^{zc}$ where $z$ is the survival rate and $c$ the maximum number of year of live for the species;
```

```
$N$ ← matrix of 0 with $n$ rows and $p$ columns where n is the number of specimens in the sample and p is the number of cohorts;

$Wi$ ← matrix of 1 with $n$ rows and $p$ columns where n is the number of specimens in the sample and p is the number of cohorts;

          FOR looping variable ← 1 to step

                    FOR j ← 1 to length(p)

                              N(all the row, column j) ← probability of the specimen for each of the cohorts;

                    END

          END

SET $x0$ as a vector ← [$L_\infty$, $L$, $k$, $devs$] ▶ These are the initial estimations for each of the parameters to be optimised

SET $t$ as a vector of integer containing the ages (in years) of the cohorts;

[copt, xopt(1), xopt(2), xopt(3), xopt(4), ……. xopt(3+$p$)] ← compute the FUNCTION ESTIMATION/MAXIMIZATION

▶ The function produces a series of output. The first (copt) is the best value of the Max Likelihood function, the following are: xopt(1) ← Optimised value of $L_\infty$, xopt(2) ← Optimised value of $L$, xopt(3) ← Optimised value of $k$, xopt(4)…. xopt(3+$p$) ← Optimised values of $devs$.
```

8.3 Generation of hypothetical populations

▶ NECESSARY INPUT

L_∞ ▶ Parameter of the von Bertalanffy equation;

k ▶ Parameter of the von Bertalanffy equation;

t_0 ▶ Parameter of the von Bertalanffy equation;

z_0 ▶ Value of mortality rate;

cohort ▶ Number of cohort in the population;

mm ▶ Vector of Values of the mean length of each cohort;

ss ▶ Vector of Values of the Standard deviation of each cohort;

Nmr ▶ Size of the population generated;

▶ GENERATE THE VIRTUAL POPULATION

```
$z \leftarrow 1-z_0$

$pini \leftarrow (1-z_0)/(1-z_0^7)$;

FOR looping variable ← 0 TO cohort

    $p(looping\ variable) \leftarrow pini*z_0^{looping\ variable}$

END

$tt \leftarrow -\log(1-mm/L_\infty)/k$;

xdat ←Vector of size Nmr composed by random (normally distributed) values ranging between 0 and 1

FOR looping variable ← 0 TO cohort

    $media(looping\ variable) \leftarrow L_\infty*(1-L*e^{(-k*tt)})$;

END
```

```
$s2=ss^2$;

y ← exp(-($(xdat-mm)^2$)/s2/2) / square root (2*π)/ss;

zz ← Vector of size Nmr composed by random (uniformly distributed) values ranging between 0 and 1

classe ← [cohort+1-sum(zz,2)];

FOR looping variable ← 0 TO Nmr

    xdat(looping variable) ← xdat(looping variable) * ss(classe(looping variable)) + media(classe(looping variable));

END
```

8.4 Sub-sampling

▶ **NECESSARY INPUT**

cycle_of_extract	▶ Number of sub-sample
dim_of_extract	▶ Size of each sub-samples
Nmr	▶ Size of the original population;

```
FOR looping variable ← 1 TO cycle_of_extract
    sub ← Vector of size dim_of_extract composed by random (uniformly distributed) values ranging between 1 and Nmr;
    subxdat ← Vector of 0 with the same dimension of dim_of_extract;
        FOR looping variable ←1 TO dim_of_extract
            index ← sub(ex);
            subxdat(ex)←xdat(index);
        END;
END;
```

8.5 The ELEFAN I method

▶ NECESSARY INPUT

Vector *xdat* ▶ Original length data (fish length);

Vector *val* ▶ Vector of the extremes of the bins for the chosen partition

▶ DEFINING THE VON BERTALANFFY FUNCTION

```
$vonB \leftarrow L_\infty * (1- e^{(-k*x)})$;
```

▶ DEFINING THE FUNCTION RECONSTRUCT

This function applies the transformation of data described by Brey *et al*. (1988).

▶ DEFINING THE FUNCTION COUNTPEAKS

```
peak←0;
llpeak←[0 ll 0];
FOR  looping variable ← 2 TO (length(llpeak)-1))
        IF    llpeak(looping variable) >= llpeak(looping variable-1) &
              llpeak(looping variable) >= llpeak(looping variable+1) &
              llpeak(looping variable) > 0 THEN
              peak=peak+1;
        ELSE
END
END
```

▶ DEFINING THE FUNCTION COMPUTEMEANS

```
means← Vector made of 0 with the same dimension of cohorts;
```

```
llpeak ← [0 ll 0];
nmean ← 0;
FOR looping variable ← 2 TO (length(llpeak)-1))
    IF  llpeak(looping variable)>=llpeak(looping variable-1) &
        llpeak(looping variable)>=llpeak(looping variable+1) &
        llpeak(looping variable)>0 THEN
            nmean ←nmean+1;
            means(1,nmean) ← (val(looping variable)+val(looping variable-1))/2;
    ELSE
END;
END;
```

▶ DEFINING THE FUNCTION COMPUTEDEVSTANDS

```
devstands ←Vector made of 0 with the same dimension of cohorts;
llpeak ← [0 ll 0];
ndev ← 0;
FOR  looping variable ← 2 TO (length(llpeak)-1))
    IF  llpeak(looping variable)>=llpeak(looping variable-1) &
        llpeak(looping variable)>=llpeak(looping variable+1) &
        llpeak(looping variable)>0 THEN
            ndev ← ndev+1;
            devstands(1,ndev) ← square root ((((occ(looping variable) + occ(looping variable-2)) - occ(looping variable-1))/6)$^2$);
```

```
                ELSE
        END;
END;
```

▶ DEFINING THE FUNCTION ELEFANSCORE

This function applies the transformation of data described by Pauly (1987).

▶ DEFINING THE FUNCTION COMPUTE_t_0

```
times ←Vector made of 0 with the same dimension of cohorts;
FOR looping variable ← 1 TO cohorts
        times(1,looping variable) ← (( log(1-(means(1,looping variable)/$L_\infty$))/k)-looping variable;
END;
$t_0$ ← -mean(times);
```

▶ DEFINING THE FUNCTION STIMAZ

```
indic ← Vector of integer ranging from 1 TO cohorts;
v1 ← Vector of real ranging from $z^{(indic(1)-1)}$ TO $z^{(indic(cohorts)-1)}$
z ← v1 * means/sum(v1)-mean(xdat);
```

▶ PERFORM THE MIXTURE ANALYSIS AND COMPUTE THE VON BERTALANFFY PARAMETERS

```
dB ← Compute the best number of bins for the vector xdat through the function Birgefunction
occB ← Compute the effective for the vector xdat through the vector val;
ll ← Compute the new vector of data through the function reconstruct;
SET AGEfirst ← 1;
SET AGEincrement ← 1;
```

cohorts ← Compute the number of cohort on vector *ll* using the function *countpeaks*;
means ← Compute the mean of each cohort on vector *ll* using the function *computemeans*;
devs ← Compute the standard deviation of cohort on vector *ll* using the function *computedevstands*);

k, L_∞ ← Compute these parameter on vector *ll* by maximisation of function *elefanscore*;
t_0 ← Compute this parameter on vector *ll* using the function *compute_*t_0;

z ← Compute this parameter on vector *ll* using the function *stimaz;*

8.6 The Bhattacharya method

▶ NECESSARY INPUT

Vector *occ*	▶ Vector of the effective for each of the length frequency class in which the sample was divided;
Vector *val*	▶ Vector of the extremes for each of the length frequency class in which the sample was divided;

▶ COMPUTE THE COORDINATES FOR THE 2D PLOT

```
locc ← length(occ)-1;

ratio ← vector of 0 with the same dimension of locc;

xplot ← vector of 0 with the same dimension of locc;

yplot ← vector of 0 with the same dimension of locc;

coorti ← 0; ▶ Number of detected cohorts;

        FOR looping variable ← 2 to length(occ)

                IF occ(looping variable -1) <> 0 THEN

                        ratio(looping variable -1) ← occ(looping variable)/occ(looping variable -1);

            ELSE ratio(looping variable) ← 0

                END

        END
```

▶ COMPUTE THE LOG OF THE RATES

```
        FOR looping variable ← 1 to locc

                IF ratio(looping variable) > 0 THEN

                        yplot(looping variable) ← Log(ratio(looping variable));
```

```
            ELSE yplot(looping variable) ← 0
                END
        xplot(looping variable)=(val(looping variable +1)+val(looping variable))/2;
        END
```

▶ **DRAW THE 2D PLOT OF POINTS**

Draw 2D plot with *xplot* and *yplot* as imput of X and Y axes, respectively;

▶ **SELECT THE SET OF THREE POINTS FOR THE REGRESSION**

▶ **CREATE THE EMPTY VECTORS FOR THE COORDINATES**

```
SET xtrex ← [0 0 0];
SET ytrex ← [0 0 0];
```

▶ **ASSIGN THE POINTS AND COMPUTE THE VALUE OF K FOR THE AVAILABLE SET OF THREE POINTS**

```
        FOR looping variable ← 1 to length(ypoint) -2
                xtrex(1) ← xplot(looping variable)
                ytrex(1) ← yplot(looping variable)
                xtrex(2) ← xplot(looping variable+1)
                ytrex(2) ← yplot(looping variable+1)
                xtrex(3) ← xplot(looping variable+2)
                ytrex(3) ← yplot(looping variable+2)
        END
```

A ← slope parameter of the linear regression computed in the points of coordinates *xtrex ytrex*;

B ← y-intercept of the linear regression computed in the points of coordinates *xtrex ytrex*;

▶ STORE THE SLOPE FOR THE K-SH SET OF THREE POINTS

```
reg(k) ← A;
```

▶ COMPUTE THE REGRESSION COEFFICENT (R) FOR EACH SET OF THREE POINTS

```
fre ← a matrix made of 1 and dimension 3 × 3;

mx ← mean(xtrex);

my ← mean(ytrex);

d1 ← xtrex(1)-mx;

d2 ← xtrex(2)-mx;

d3 ← xtrex(3)-mx;

d4 ← ytrex(1)-my;

d5 ← ytrex(2)-my;

d6 ← ytrex(3)-my;

cov ← (d1*d4+d2*d5+d3*d6)/3;

devsx=square root((($(xtrex(1)-mx)^2+(xtrex(2)-mx)^2+(xtrex(3)-mx)^2$))/3);

        IF devsx = 0 THEN

                devsx ← 1;

        ELSE

        END

devsy=square root((($(ytrex(1)-my)^2+(ytrex(2)-my)^2+(ytrex(3)-my)^2$))/3);

        IF devsy = 0 THEN

                devsy ← 1;
```

```
        ELSE

        END

▶ STORE THE REGRESSION COEFFICENT (R) FOR THE K-SH SET OF THREE POINTS

rho(k)=cov/(devsx*devsy);

END

▶ INITIALIZE THE VECTOR WHICH DEFINE THE POSITION

poscoo= vector of 0 with the same dimension of reg;

▶ DETECT THE "RIGHT" SETS OF THREE POINTS, THAT IS THE COHORTS

        FOR looping variable ← 2: length(reg)-1

                IF reg(looping variable) < reg(looping variable -1) & reg(looping variable) < reg(looping variable +1) & reg(looping variable)<0 & rho(looping variable)<-RC & yplot(looping variable -1) <> 0 THEN

                coorti ← coorti+1;

                poscoo(coorti) ← looping variable -1;

                ELSE

                END

        END

        FOR looping variable ← 1 TO coorti

                tri ← 3*( looping variable -1);

                        for k ← 1 TO 3

                        pospunti(tri+k)=poscoo(looping variable)+k-1;

                        END;

        END;
```

▶ DEFINE THE VECTORS OF THE POINTS FOR THE COHORTS

```
Mx ← matrix of 0 with coorti row and 3 column;

My ← matrix of 0 with coorti row and 3 column;

          FOR looping variable1 ←1:coorti

                    FOR looping variable2  ← 1 TO 3

                    shift←poscoo(looping variable1);

                    Mx(looping variable1,k)  ← xplot(looping variable2  -1+k);

                    My(looping variable1,k)  ← yplot(looping variable2  -1+k);

                    END

          END
```

▶ ENLARGE THE COHORTS BY TACKING THE NEAREST POINTS

```
Matdis ← matrix of 0 with length(xplot) row and coorti column;

          FOR looping variable ← 1 TO coorti

                    IF looping variable  < coorti THEN

                              b ← poscoo (looping variable);

                              o ← poscoo (looping variable  + 1);

                    ELSE

                              b ← poscoo (looping variable);

                              o ← length (xplot);

                END

          xser ← Mx(looping variable,1:3);

          yser ← My(looping variable,1:3);
```

```
    m ← slope parameter of the linear regression computed in the points of coordinates xser yser;

    q ← y-intercept of the linear regression computed in the points of coordinates xser yser;

        SET rangem ← 1;

    dist ← vector of 0 with the same dimension of xplot;

    SET puntiaggiunti ← 0;

    ▶ COMPUTE THE DISTANCE BETWEEN EACH POINT AND THE LINE AND, EVENTUALLY, ADD THE POINT TO THE COHORT

            FOR looping variable ← b TO o

                dist(i) ← square root (((yplot(looping variable)-m*xplot(looping variable)-q)/( square root (1+$m^2$)))$^2$);

                Matdis(looping variable, c)=dist(looping variable);

                IF dist(looping variable) < rangem THEN

                    puntiaggiunti ← puntiaggiunti + 1;

                    Mx(c,3+puntiaggiunti)=xplot(i);

                    My(c,3+puntiaggiunti)=yplot(i);

                ELSE BREAK

                END;

            END;

    END;

▶ COMPUTE THE DISTANCE MEANS AND THE STANDARD DEVIATIONS FOR EACH COHORT

means ← vector of 0 with the same dimension of coorti;

devs ← vector of 0 with the same dimension of coorti;
```

```
          FOR looping variable ← 1 TO coorti
                    xt ← Mx (looping variable, all column);
                    yt ← My (looping variable, all column);
                    j ← 0;
                    FOR looping variable ← 1 TO length(xt)
                              IF yt(looping variable) <> 0 THEN
                                        j ← j+1;
                                        xr(j) ← xt(looping variable);
                                        yr(j) ← yt(looping variable);
                              ELSE
                              END;
                    END;
a ← slope parameter of the linear regression computed in the points of coordinates xr yr;
b ← y-intercept of the linear regression computed in the points of coordinates xr yr;
          IF a < 0 THEN
                    means(looping variable) ← - b / a;
                    devs(looping variable) ← square root (- ampclass / a );
          ELSE
                    means(looping variable) ← 0;
                    devs(looping variable) ← 0;
          END;
```

9. APPENDIX B

Appendix Table B.1a Estimates and corresponding percentage bias of L_∞ and k obtained in the sub-sampling of 100 length measurements using the two partitions for grouping the Red mullet data. The class numbers and the corresponding class widths for the data partition generated using the Birgé and Rozenholc algorithm are also reported.

Sample size = 100 length measurements											
	Estimates							% Bias			
	Birgè and Rozenholc algorithm				1 cm			Birgè and Rozenholc algorithm		1 cm	
	L_∞ *(cm)*	*k (year^{-1})*	*class number*	*class width (cm)*	L_∞ *(cm)*	*k (year^{-1})*	*class number*	L_∞	*k*	L_∞	*k*
1	18.00	0.50	8	1.96	17.00	0.30	16	-14.08	6.38	-18.85	-36.17
2	20.00	0.42	9	1.93	20.00	0.20	17	-4.53	-10.64	-4.53	-57.45
3	16.90	0.20	11	1.38	17.00	0.20	15	-19.33	-57.45	-18.85	-57.45
4	17.60	0.54	7	2.16	17.00	0.20	15	-15.99	14.89	-18.85	-57.45
5	20.60	0.42	8	2.14	18.00	0.34	17	-1.67	-10.64	-14.08	-27.66
6	19.10	1.00	6	2.51	17.00	0.20	17	-8.83	112.77	-18.85	-57.45
7	19.10	0.28	17	0.89	17.00	0.20	15	-8.83	-40.43	-18.85	-57.45
8	18.00	0.56	7	2.23	17.00	0.30	16	-14.08	19.15	-18.85	-36.17
9	20.90	1.00	6	2.90	19.00	0.36	18	-0.24	112.77	-9.31	-23.40
10	19.50	0.30	9	1.99	21.00	0.26	18	-6.92	-36.17	0.24	-44.68
11	17.20	1.00	6	2.16	17.00	0.20	13	-17.90	112.77	-18.85	-57.45
12	19.90	0.50	9	1.76	17.00	0.20	16	-5.01	6.38	-18.85	-57.45
13	18.90	0.94	8	2.06	20.00	0.24	16	-9.79	100.00	-4.53	-48.94
14	19.80	0.92	7	2.25	17.00	0.30	16	-5.49	95.74	-18.85	-36.17
15	18.20	1.00	6	2.43	17.00	0.20	15	-13.13	112.77	-18.85	-57.45
16	16.80	0.66	6	2.50	17.00	0.44	15	-19.81	40.43	-18.85	-6.38
17	18.40	0.20	13	1.34	19.00	0.20	18	-12.17	-57.45	-9.31	-57.45
18	17.90	0.30	12	1.33	17.00	0.30	15	-14.56	-36.17	-18.85	-36.17
19	20.60	0.94	7	2.55	21.00	0.22	17	-1.67	100.00	0.24	-53.19
20	17.60	1.00	5	2.68	17.00	0.20	13	-15.99	112.77	-18.85	-57.45
21	18.50	0.52	7	2.25	17.00	0.20	16	-11.69	10.64	-18.85	-57.45
22	22.10	1.00	8	2.30	19.00	0.36	18	5.49	112.77	-9.31	-23.40
23	21.60	0.38	9	2.06	19.00	0.40	18	3.10	-19.15	-9.31	-14.89
24	21.00	0.42	8	2.28	19.00	0.20	18	0.24	-10.64	-9.31	-57.45
25	17.70	0.20	12	1.39	17.00	0.20	17	-15.51	-57.45	-18.85	-57.45
26	18.50	1.00	6	2.40	16.00	0.86	14	-11.69	112.77	-23.63	82.98
27	20.80	0.42	8	2.11	18.00	0.20	17	-0.72	-10.64	-14.08	-57.45
28	19.40	0.50	7	2.40	18.00	0.30	17	-7.40	6.38	-14.08	-36.17
29	17.10	0.56	7	2.17	18.00	0.72	15	-18.38	19.15	-14.08	53.19
30	20.30	0.42	8	2.22	18.00	0.34	18	-3.10	-10.64	-14.08	-27.66
31	18.30	1.00	5	2.86	17.00	0.20	14	-12.65	112.77	-18.85	-57.45
32	21.40	0.80	8	2.18	19.00	0.20	17	2.15	70.21	-9.31	-57.45
33	17.20	0.56	6	2.18	17.00	0.20	13	-17.90	19.15	-18.85	-57.45
34	19.40	0.96	7	2.22	18.00	0.30	15	-7.40	104.26	-14.08	-36.17
35	18.60	1.00	6	2.45	17.00	0.20	14	-11.22	112.77	-18.85	-57.45
36	20.80	0.28	11	1.53	19.00	0.36	17	-0.72	-40.43	-9.31	-23.40
37	17.70	1.00	6	2.21	17.00	0.20	13	-15.51	112.77	-18.85	-57.45
38	18.20	0.56	7	2.24	17.00	0.20	16	-13.13	19.15	-18.85	-57.45
39	19.40	0.96	7	2.20	17.00	0.20	15	-7.40	104.26	-18.85	-57.45
40	18.00	0.52	7	2.21	17.00	0.20	15	-14.08	10.64	-18.85	-57.45
41	17.60	0.54	7	2.11	16.00	0.32	15	-15.99	14.89	-23.63	-31.91
42	17.20	0.60	6	2.36	17.00	0.20	14	-17.90	27.66	-18.85	-57.45
43	19.10	0.96	7	2.36	17.00	0.28	17	-8.83	104.26	-18.85	-40.43
44	16.10	0.20	15	0.92	17.00	0.20	14	-23.15	-57.45	-18.85	-57.45
45	21.20	1.00	6	3.14	21.00	0.30	19	1.19	112.77	0.24	-36.17
46	19.30	0.98	7	2.39	19.00	0.20	16	-7.88	108.51	-9.31	-57.45
47	16.90	0.64	6	2.36	17.00	0.20	14	-19.33	36.17	-18.85	-57.45
48	21.00	1.00	9	1.98	19.00	0.36	18	0.24	112.77	-9.31	-23.40
49	16.30	0.68	6	2.35	17.00	0.20	14	-22.20	44.68	-18.85	-57.45
50	19.80	1.00	8	1.95	17.00	0.20	16	-5.49	112.77	-18.85	-57.45
51	17.10	0.20	13	1.04	15.00	0.36	13	-18.38	-57.45	-28.40	-23.40
52	18.60	1.00	6	2.06	16.00	0.32	14	-11.22	112.77	-23.63	-31.91
53	20.10	0.86	8	2.28	20.00	0.52	18	-4.06	82.98	-4.53	10.64
54	21.70	0.26	9	2.11	21.00	0.20	19	3.58	-44.68	0.24	-57.45
55	18.20	1.00	8	1.83	16.00	0.32	15	-13.13	112.77	-23.63	-31.91
56	19.10	0.50	7	2.36	18.00	0.20	16	-8.83	6.38	-14.08	-57.45
57	17.10	0.20	13	1.18	17.00	0.20	16	-18.38	-57.45	-18.85	-57.45
58	19.00	0.96	7	2.33	17.00	0.20	17	-9.31	104.26	-18.85	-57.45
59	16.40	0.74	7	1.84	17.00	0.20	13	-21.72	57.45	-18.85	-57.45
60	19.30	0.30	15	1.07	17.00	0.20	16	-7.88	-36.17	-18.85	-57.45
61	19.50	1.00	6	2.60	17.00	0.20	15	-6.92	112.77	-18.85	-57.45
62	19.20	0.94	7	2.26	17.00	0.30	15	-8.35	100.00	-18.85	-36.17
63	17.50	0.20	12	1.26	17.00	0.20	15	-16.47	-57.45	-18.85	-57.45
64	19.60	0.48	7	2.28	20.00	0.24	16	-6.44	2.13	-4.53	-48.94
65	17.60	0.20	13	1.16	17.00	0.20	15	-15.99	-57.45	-18.85	-57.45
66	17.00	0.82	7	2.06	16.00	0.20	14	-18.85	74.47	-23.63	-57.45
67	19.50	0.74	8	1.97	17.00	0.20	15	-6.92	57.45	-18.85	-57.45
68	17.90	0.54	7	2.30	17.00	0.20	16	-14.56	14.89	-18.85	-57.45
69	18.30	0.48	8	1.91	17.00	0.20	15	-12.65	2.13	-18.85	-57.45
70	21.40	0.40	9	2.04	21.00	0.26	19	2.15	-14.89	0.24	-44.68
71	21.30	0.40	8	2.20	21.00	0.26	17	1.67	-14.89	0.24	-44.68
72	18.10	0.50	8	2.01	20.00	0.24	16	-13.60	6.38	-4.53	-48.94
73	18.40	1.00	7	2.04	16.00	0.38	14	-12.17	112.77	-23.63	-19.15
74	16.20	0.66	6	2.35	16.00	0.32	14	-22.67	40.43	-23.63	-31.91
75	18.30	0.94	8	2.07	19.00	0.60	16	-12.65	100.00	-9.31	27.66
76	20.10	1.00	6	2.73	17.00	0.20	16	-4.06	112.77	-18.85	-57.45
77	18.70	0.56	6	2.52	17.00	0.20	15	-10.74	19.15	-18.85	-57.45
78	19.10	1.00	7	2.14	16.00	0.32	15	-8.83	112.77	-23.63	-31.91
79	18.00	0.60	8	1.88	17.00	0.20	15	-14.08	27.66	-18.85	-57.45
80	18.40	1.00	6	2.41	16.00	0.38	14	-12.17	112.77	-23.63	-19.15
81	19.70	0.58	8	2.07	19.00	0.36	16	-5.97	23.40	-9.31	-23.40
82	18.40	0.58	6	2.61	17.00	0.20	15	-12.17	23.40	-18.85	-57.45
83	22.50	1.00	8	2.37	21.00	0.34	19	7.40	112.77	0.24	-27.66
84	18.60	1.00	6	2.38	17.00	0.20	14	-11.22	112.77	-18.85	-57.45
85	20.80	0.44	7	2.51	18.00	0.34	18	-0.72	-6.38	-14.08	-27.66
86	21.10	0.80	8	2.22	19.00	0.20	17	0.72	70.21	-9.31	-57.45
87	19.40	1.00	7	2.29	20.00	0.24	16	-7.40	112.77	-4.53	-48.94
88	18.10	0.26	15	1.11	20.00	0.24	17	-13.60	-44.68	-4.53	-48.94
89	18.00	0.20	14	1.19	18.00	0.20	17	-14.08	-57.45	-14.08	-57.45
90	18.70	0.58	6	2.65	17.00	0.30	16	-10.74	23.40	-18.85	-36.17
91	20.10	0.94	7	2.26	17.00	0.20	16	-4.06	100.00	-18.85	-57.45
92	18.20	1.00	8	2.07	19.00	0.36	16	-13.13	112.77	-9.31	-23.40
93	19.80	0.94	7	2.41	18.00	0.30	16	-5.49	100.00	-14.08	-36.17
94	18.20	0.58	9	1.67	17.00	0.20	15	-13.13	23.40	-18.85	-57.45
95	20.30	0.90	7	2.37	19.00	0.42	16	-3.10	91.49	-9.31	-10.64
96	18.20	1.00	5	2.82	17.00	0.20	14	-13.13	112.77	-18.85	-57.45
97	18.10	0.66	8	1.93	17.00	0.30	15	-13.60	40.43	-18.85	-36.17
98	18.90	1.00	5	3.10	16.00	0.20	16	-9.79	112.77	-23.63	-57.45
99	16.80	0.30	12	1.22	16.00	0.20	15	-19.81	-36.17	-23.63	-57.45
100	19.40	1.00	6	2.60	17.00	0.88	15	-7.40	112.77	-18.85	87.23

Appendix Table B.1b Estimates and corresponding percentage bias of L_∞ and k obtained in the sub-sampling of 200 length measurements using the two partitions for grouping the Red mullet data. The class numbers and the corresponding class widths for the data partition generated using the Birgé and Rozenholc algorithm are also reported.

Sample size = 200 length measurements											
	Estimates							**% Bias**			
	Birgè and Rozenholc algorithm				1 cm			Birgè and Rozenholc algorithm		1 cm	
	L_∞ (cm)	k (year^{-1})	class number	class width (cm)	L_∞ (cm)	k (year^{-1})	class number	L_∞	k	L_∞	k
1	21.00	0.42	8	2.18	21.00	0.22	17	0.24	-10.64	0.24	-53.19
2	19.00	0.26	11	1.44	17.00	0.20	16	-9.31	-44.68	-18.85	-57.45
3	20.10	0.26	13	1.33	21.00	0.22	17	-4.06	-44.68	0.24	-53.19
4	18.40	0.52	7	2.28	17.00	0.28	16	-12.17	10.64	-18.85	-40.43
5	20.90	0.92	7	2.65	19.00	0.20	19	-0.24	95.74	-9.31	-57.45
6	19.80	0.46	7	2.30	17.00	0.28	16	-5.49	-2.13	-18.85	-40.43
7	18.20	0.20	18	0.92	20.00	0.24	16	-13.13	-57.45	-4.53	-48.94
8	18.20	0.28	20	0.77	16.00	0.32	16	-13.13	-40.43	-23.63	-31.91
9	18.40	0.20	23	0.76	18.00	0.20	18	-12.17	-57.45	-14.08	-57.45
10	20.60	0.94	7	2.55	21.00	0.30	17	-1.67	100.00	0.24	-36.17
11	21.70	0.40	8	2.30	21.00	0.20	18	3.58	-14.89	0.24	-57.45
12	21.90	0.40	8	2.34	19.00	0.20	18	4.53	-14.89	-9.31	-57.45
13	17.70	0.20	11	1.52	17.00	0.20	17	-15.51	-57.45	-18.85	-57.45
14	21.00	0.30	18	0.95	21.00	0.20	17	0.24	-36.17	0.24	-57.45
15	20.60	0.22	19	0.93	18.00	0.34	18	-1.67	-53.19	-14.08	-27.66
16	19.20	0.24	23	0.77	19.00	0.36	17	-8.35	-48.94	-9.31	-23.40
17	19.10	0.48	7	2.26	17.00	0.20	15	-8.83	2.13	-18.85	-57.45
18	18.90	0.24	20	0.87	20.00	0.24	17	-9.79	-48.94	-4.53	-48.94
19	18.00	0.56	7	2.27	20.00	0.24	16	-14.08	19.15	-4.53	-48.94
20	17.40	0.20	14	1.13	17.00	0.20	15	-16.95	-57.45	-18.85	-57.45
21	17.70	0.20	12	1.25	17.00	0.20	15	-15.51	-57.45	-18.85	-57.45
22	20.10	1.00	6	2.75	19.00	0.20	17	-4.06	112.77	-9.31	-57.45
23	19.70	0.34	12	1.57	21.00	0.20	19	-5.97	-27.66	0.24	-57.45
24	21.40	0.30	21	0.85	19.00	0.30	18	2.15	-36.17	-9.31	-36.17
25	18.40	0.52	7	2.26	17.00	0.20	16	-12.17	10.64	-18.85	-57.45
26	18.60	1.00	6	2.42	17.00	0.20	14	-11.22	112.77	-18.85	-57.45
27	20.60	0.88	8	2.40	20.00	0.24	19	-1.67	87.23	-4.53	-48.94
28	18.10	0.20	19	0.90	18.00	0.20	17	-13.60	-57.45	-14.08	-57.45
29	18.60	0.26	15	1.09	17.00	0.20	17	-11.22	-44.68	-18.85	-57.45
30	17.50	0.20	15	1.07	17.00	0.20	16	-16.47	-57.45	-18.85	-57.45
31	17.50	0.20	22	0.72	17.00	0.30	15	-16.47	-57.45	-18.85	-36.17
32	18.10	0.20	19	0.86	17.00	0.20	16	-13.60	-57.45	-18.85	-57.45
33	17.90	0.30	12	1.26	17.00	0.20	15	-14.56	-36.17	-18.85	-57.45
34	17.90	0.54	7	2.30	17.00	0.20	16	-14.56	14.89	-18.85	-57.45
35	21.20	0.40	9	2.06	21.00	0.26	19	1.19	-14.89	0.24	-44.68
36	21.30	0.40	8	2.20	21.00	0.26	17	1.67	-14.89	0.24	-44.68
37	17.90	0.28	13	1.12	16.00	0.32	14	-14.56	-40.43	-23.63	-31.91
38	18.10	0.20	15	1.11	18.00	0.30	16	-13.60	-57.45	-14.08	-36.17
39	17.20	0.20	15	1.01	17.00	0.20	15	-17.90	-57.45	-18.85	-57.45
40	17.20	0.20	14	1.11	17.00	0.20	15	-17.90	-57.45	-18.85	-57.45
41	18.30	0.54	7	2.39	20.00	0.24	16	-12.65	14.89	-4.53	-48.94
42	21.00	0.34	19	1.00	20.00	0.50	19	0.24	-27.66	-4.53	6.38
43	19.50	0.32	22	0.82	21.00	0.30	18	-6.92	-31.91	0.24	-36.17
44	19.10	0.24	16	1.06	20.00	0.24	17	-8.83	-48.94	-4.53	-48.94
45	18.30	0.20	22	0.76	18.00	0.20	17	-12.65	-57.45	-14.08	-57.45
46	19.20	0.28	13	1.27	19.00	0.36	16	-8.35	-40.43	-9.31	-23.40
47	18.30	0.20	20	0.84	18.00	0.30	16	-12.65	-57.45	-14.08	-36.17
48	20.30	0.90	7	2.37	18.00	0.20	16	-3.10	91.49	-14.08	-57.45
49	19.20	0.26	11	1.49	17.00	0.30	16	-8.35	-44.68	-18.85	-36.17
50	17.20	0.20	13	1.22	18.00	0.30	16	-17.90	-57.45	-14.08	-36.17
51	18.70	0.28	18	0.85	17.00	0.20	15	-10.74	-40.43	-18.85	-57.45
52	18.20	0.20	12	1.38	18.00	0.24	16	-13.13	-57.45	-14.08	-48.94
53	22.00	0.38	9	2.26	22.00	0.28	20	5.01	-19.15	5.01	-40.43
54	20.10	0.22	26	0.67	21.00	0.20	17	-4.06	-53.19	0.24	-57.45
55	20.40	0.90	7	2.36	18.00	0.26	16	-2.63	91.49	-14.08	-44.68
56	20.40	0.22	18	0.94	20.00	0.24	17	-2.63	-53.19	-4.53	-48.94
57	20.00	0.34	13	1.37	19.00	0.36	18	-4.53	-27.66	-9.31	-23.40
58	19.30	0.26	16	1.03	19.00	0.36	16	-7.88	-44.68	-9.31	-23.40
59	19.70	0.42	8	2.01	17.00	0.20	16	-5.97	-10.64	-18.85	-57.45
60	18.70	0.28	12	1.24	16.00	0.32	15	-10.74	-40.43	-23.63	-31.91
61	20.20	0.22	22	0.84	21.00	0.22	19	-3.58	-53.19	0.24	-53.19
62	19.90	0.92	7	2.31	17.00	0.20	16	-5.01	95.74	-18.85	-57.45
63	19.40	0.30	16	1.19	20.00	0.20	20	-7.40	-36.17	-4.53	-57.45
64	19.30	0.98	7	2.33	18.00	0.30	16	-7.88	108.51	-14.08	-36.17
65	18.70	0.98	8	2.13	18.00	0.34	17	-10.74	108.51	-14.08	-27.66
66	20.20	0.22	22	0.83	21.00	0.30	18	-3.58	-53.19	0.24	-36.17
67	16.80	0.28	13	1.17	16.00	0.32	15	-19.81	-40.43	-23.63	-31.91
68	20.30	0.94	7	2.45	18.00	0.20	17	-3.10	100.00	-14.08	-57.45
69	18.90	0.98	7	2.23	17.00	0.20	15	-9.79	108.51	-18.85	-57.45
70	20.90	0.24	13	1.46	21.00	0.22	19	-0.24	-48.94	0.24	-53.19
71	18.30	0.28	10	1.60	17.00	0.20	16	-12.65	-40.43	-18.85	-57.45
72	18.70	0.20	15	1.16	19.00	0.36	17	-10.74	-57.45	-9.31	-23.40
73	21.50	0.28	20	0.95	22.00	0.28	19	2.63	-40.43	5.01	-40.43
74	19.30	0.24	20	0.90	19.00	0.42	18	-7.88	-48.94	-9.31	-10.64
75	17.80	0.28	15	1.07	17.00	0.20	16	-15.04	-40.43	-18.85	-57.45
76	20.00	0.94	7	2.43	19.00	0.36	17	-4.53	100.00	-9.31	-23.40
77	18.40	1.00	6	2.39	16.00	0.32	14	-12.17	112.77	-23.63	-31.91
78	18.30	1.00	7	2.19	17.00	0.30	15	-12.65	112.77	-18.85	-36.17
79	17.30	0.28	13	1.12	16.00	0.32	15	-17.42	-40.43	-23.63	-31.91
80	19.60	1.00	6	2.65	17.00	0.30	16	-6.44	112.77	-18.85	-36.17
81	18.10	0.34	13	1.15	17.00	0.20	15	-13.60	-27.66	-18.85	-57.45
82	20.30	0.22	16	1.20	21.00	0.22	19	-3.10	-53.19	0.24	-53.19
83	20.20	0.26	12	1.42	20.00	0.24	17	-3.58	-44.68	-4.53	-48.94
84	18.30	0.28	11	1.49	18.00	0.30	16	-12.65	-40.43	-14.08	-36.17
85	21.80	0.80	8	2.36	22.00	0.28	18	4.06	70.21	5.01	-40.43
86	20.00	0.44	8	2.12	18.00	0.34	17	-4.53	-6.38	-14.08	-27.66
87	17.80	0.54	7	2.35	17.00	0.28	17	-15.04	14.89	-18.85	-40.43
88	18.80	0.50	7	2.30	17.00	0.20	16	-10.26	6.38	-18.85	-57.45
89	19.10	0.36	16	1.06	19.00	0.36	17	-8.83	-23.40	-9.31	-23.40
90	21.70	0.28	22	0.84	22.00	0.28	18	3.58	-40.43	5.01	-40.43
91	21.40	0.80	8	2.25	20.00	0.24	18	2.15	70.21	-4.53	-48.94
92	18.50	0.26	14	1.10	17.00	0.20	16	-11.69	-44.68	-18.85	-57.45
93	21.60	0.28	21	0.93	21.00	0.22	19	3.10	-40.43	0.24	-53.19
94	21.90	0.20	14	1.37	20.00	0.24	20	4.53	-57.45	-4.53	-48.94
95	19.70	0.98	7	2.38	18.00	0.20	16	-5.97	108.51	-14.08	-57.45
96	18.20	0.20	19	0.89	18.00	0.20	17	-13.13	-57.45	-14.08	-57.45
97	19.50	0.26	11	1.48	17.00	0.20	16	-6.92	-44.68	-18.85	-57.45
98	18.50	1.00	6	2.39	17.00	0.20	14	-11.69	112.77	-18.85	-57.45
99	18.20	0.28	19	0.90	18.00	0.30	17	-13.13	-40.43	-14.08	-36.17
100	19.70	0.26	18	0.93	20.00	0.24	17	-5.97	-44.68	-4.53	-48.94

Appendix Table B.1c Estimates and corresponding percentage bias of L_∞ and k obtained in the sub-sampling of 500 length measurements using the two partitions for grouping the Red mullet data. The class numbers and the corresponding class widths for the data partition generated using the Birgé and Rozenholc algorithm are also reported.

Sample size = 500 length measurements												
	Estimates							% Bias				
	Birgè and Rozenholc algorithm				1 cm			Birgè and Rozenholc algorithm		1 cm		
	L_∞ (cm)	k (year^{-1})	class number	class width (cm)	L_∞ (cm)	k (year^{-1})	class number	L_∞	k	L_∞	k
1	18.60	0.20	33	0.53	18.00	0.20	18	-11.22	-57.45	-14.08	-57.45
2	19.20	0.34	21	0.87	21.00	0.30	18	-8.35	-27.66	0.24	-36.17
3	19.50	0.30	24	0.78	22.00	0.28	19	-6.92	-36.17	5.01	-40.43
4	18.20	0.20	26	0.65	18.00	0.20	17	-13.13	-57.45	-14.08	-57.45
5	20.30	0.30	27	0.68	21.00	0.22	18	-3.10	-36.17	0.24	-53.19
6	20.90	0.28	28	0.68	20.00	0.20	19	-0.24	-40.43	-4.53	-57.45
7	21.10	0.24	22	0.85	21.00	0.22	19	0.72	-48.94	0.24	-53.19
8	21.50	0.22	31	0.59	19.00	0.20	18	2.63	-53.19	-9.31	-57.45
9	21.30	0.22	26	0.73	20.00	0.24	19	1.67	-53.19	-4.53	-48.94
10	20.20	0.28	21	0.90	21.00	0.22	19	-3.58	-40.43	0.24	-53.19
11	19.50	0.20	26	0.70	20.00	0.24	18	-6.92	-57.45	-4.53	-48.94
12	17.90	0.20	27	0.61	17.00	0.20	17	-14.56	-57.45	-18.85	-57.45
13	21.80	0.26	21	0.94	22.00	0.28	20	4.06	-44.68	5.01	-40.43
14	16.90	0.20	18	0.87	17.00	0.20	16	-19.33	-57.45	-18.85	-57.45
15	20.40	0.24	30	0.64	22.00	0.28	20	-2.63	-48.94	5.01	-40.43
16	20.70	0.22	25	0.71	21.00	0.30	17	-1.19	-53.19	0.24	-36.17
17	20.10	0.24	31	0.58	21.00	0.22	18	-4.06	-48.94	0.24	-53.19
18	19.80	0.32	14	1.23	18.00	0.20	17	-5.49	-31.91	-14.08	-57.45
19	22.20	0.26	17	1.12	22.00	0.28	19	5.97	-44.68	5.01	-40.43
20	20.80	0.22	28	0.65	18.00	0.30	18	-0.72	-53.19	-14.08	-36.17
21	19.90	0.22	25	0.68	18.00	0.34	17	-5.01	-53.19	-14.08	-27.66
22	19.00	0.32	23	0.75	18.00	0.20	17	-9.31	-31.91	-14.08	-57.45
23	19.00	0.20	20	0.82	17.00	0.20	17	-9.31	-57.45	-18.85	-57.45
24	23.00	0.20	42	0.47	22.00	0.28	19	9.79	-57.45	5.01	-40.43
25	21.00	0.20	30	0.64	21.00	0.22	19	0.24	-57.45	0.24	-53.19
26	19.50	0.34	17	1.01	19.00	0.36	18	-6.92	-27.66	-9.31	-23.40
27	22.50	0.24	25	0.78	21.00	0.20	20	7.40	-48.94	0.24	-57.45
28	19.80	0.24	26	0.65	19.00	0.36	17	-5.49	-48.94	-9.31	-23.40
29	17.30	0.20	25	0.63	17.00	0.20	16	-17.42	-57.45	-18.85	-57.45
30	22.30	0.26	22	0.90	21.00	0.26	20	6.44	-44.68	0.24	-44.68
31	19.70	0.20	25	0.75	19.00	0.20	19	-5.97	-57.45	-9.31	-57.45
32	19.40	0.32	25	0.73	21.00	0.30	19	-7.40	-31.91	0.24	-36.17
33	22.00	0.20	20	0.95	20.00	0.24	19	5.01	-57.45	-4.53	-48.94
34	21.20	0.30	17	1.21	22.00	0.28	21	1.19	-36.17	5.01	-40.43
35	19.90	0.24	25	0.70	20.00	0.24	18	-5.01	-48.94	-4.53	-48.94
36	18.80	0.20	18	0.96	18.00	0.20	17	-10.26	-57.45	-14.08	-57.45
37	18.50	0.20	17	1.01	18.00	0.20	17	-11.69	-57.45	-14.08	-57.45
38	16.90	0.20	19	0.83	17.00	0.20	16	-19.33	-57.45	-18.85	-57.45
39	21.80	0.20	27	0.71	19.00	0.20	19	4.06	-57.45	-9.31	-57.45
40	21.70	0.20	27	0.71	20.00	0.24	20	3.58	-57.45	-4.53	-48.94
41	18.30	0.20	24	0.72	18.00	0.20	17	-12.65	-57.45	-14.08	-57.45
42	18.00	0.28	20	0.83	17.00	0.20	17	-14.08	-40.43	-18.85	-57.45
43	21.00	0.24	29	0.65	21.00	0.30	19	0.24	-48.94	0.24	-36.17
44	20.00	0.24	28	0.66	22.00	0.28	18	-4.53	-48.94	5.01	-40.43
45	20.50	0.24	32	0.59	20.00	0.24	19	-2.15	-48.94	-4.53	-48.94
46	18.30	0.20	23	0.73	18.00	0.20	16	-12.65	-57.45	-14.08	-57.45
47	18.80	0.20	41	0.42	20.00	0.24	18	-10.26	-57.45	-4.53	-48.94
48	21.70	0.20	26	0.73	19.00	0.20	19	3.58	-57.45	-9.31	-57.45
49	18.90	0.20	26	0.68	18.00	0.20	17	-9.79	-57.45	-14.08	-57.45
50	19.20	0.20	29	0.60	18.00	0.20	18	-8.35	-57.45	-14.08	-57.45
51	20.30	0.22	21	0.81	18.00	0.26	17	-3.10	-53.19	-14.08	-44.68
52	17.80	0.20	24	0.68	17.00	0.20	16	-15.04	-57.45	-18.85	-57.45
53	21.40	0.26	19	1.09	22.00	0.28	21	2.15	-44.68	5.01	-40.43
54	21.90	0.28	24	0.78	19.00	0.20	19	4.53	-40.43	-9.31	-57.45
55	20.80	0.30	23	0.86	19.00	0.20	19	-0.72	-36.17	-9.31	-57.45
56	20.10	0.20	38	0.49	22.00	0.28	18	-4.06	-57.45	5.01	-40.43
57	20.90	0.40	9	2.03	19.00	0.20	18	-0.24	-14.89	-9.31	-57.45
58	20.40	0.30	27	0.68	20.00	0.24	19	-2.63	-36.17	-4.53	-48.94
59	21.90	0.28	26	0.72	22.00	0.28	19	4.53	-40.43	5.01	-40.43
60	21.10	0.30	26	0.72	21.00	0.30	19	0.72	-36.17	0.24	-36.17
61	18.30	0.20	23	0.74	20.00	0.24	17	-12.65	-57.45	-4.53	-48.94
62	19.80	0.24	26	0.63	17.00	0.20	17	-5.49	-48.94	-18.85	-57.45
63	18.40	0.20	22	0.78	18.00	0.20	17	-12.17	-57.45	-14.08	-57.45
64	20.80	0.30	26	0.70	20.00	0.24	18	-0.72	-36.17	-4.53	-48.94
65	20.00	0.20	32	0.58	22.00	0.28	19	-4.53	-57.45	5.01	-40.43
66	19.80	0.44	8	2.15	18.00	0.20	17	-5.49	-6.38	-14.08	-57.45
67	19.40	0.20	28	0.61	18.00	0.20	17	-7.40	-57.45	-14.08	-57.45
68	18.30	0.20	21	0.82	18.00	0.26	17	-12.65	-57.45	-14.08	-44.68
69	20.80	0.28	26	0.72	19.00	0.32	19	-0.72	-40.43	-9.31	-31.91
70	18.00	0.20	21	0.80	18.00	0.26	17	-14.08	-57.45	-14.08	-44.68
71	20.40	0.24	29	0.60	20.00	0.24	18	-2.63	-48.94	-4.53	-48.94
72	19.10	0.20	25	0.73	19.00	0.20	18	-8.83	-57.45	-9.31	-57.45
73	19.80	0.24	35	0.50	21.00	0.30	18	-5.49	-48.94	0.24	-36.17
74	20.60	0.30	21	0.91	19.00	0.20	19	-1.67	-36.17	-9.31	-57.45
75	21.90	0.20	37	0.52	22.00	0.28	19	4.53	-57.45	5.01	-40.43
76	20.90	0.30	21	0.87	19.00	0.20	19	-0.24	-36.17	-9.31	-57.45
77	20.30	0.32	24	0.75	21.00	0.30	18	-3.10	-31.91	0.24	-36.17
78	19.60	0.34	20	0.90	21.00	0.30	18	-6.44	-27.66	0.24	-36.17
79	19.30	0.26	18	0.98	21.00	0.30	17	-7.88	-44.68	0.24	-36.17
80	22.80	0.20	24	0.92	22.00	0.28	22	8.83	-57.45	5.01	-40.43
81	21.00	0.22	24	0.78	19.00	0.20	19	0.24	-53.19	-9.31	-57.45
82	21.70	0.22	23	0.83	21.00	0.22	19	3.58	-53.19	0.24	-53.19
83	20.10	0.30	16	1.18	21.00	0.30	19	-4.06	-36.17	0.24	-36.17
84	20.70	0.22	24	0.75	21.00	0.22	18	-1.19	-53.19	0.24	-53.19
85	19.40	0.34	21	0.86	19.00	0.20	18	-7.40	-27.66	-9.31	-57.45
86	20.40	0.30	16	1.09	18.00	0.20	17	-2.63	-36.17	-14.08	-57.45
87	20.70	0.30	21	0.85	19.00	0.20	18	-1.19	-36.17	-9.31	-57.45
88	23.70	0.20	26	0.95	23.00	0.20	25	13.13	-57.45	9.79	-57.45
89	18.10	0.28	27	0.64	20.00	0.24	17	-13.60	-40.43	-4.53	-48.94
90	20.00	0.20	28	0.65	19.00	0.20	19	-4.53	-57.45	-9.31	-57.45
91	19.00	0.26	16	0.97	17.00	0.30	15	-9.31	-44.68	-18.85	-36.17
92	21.00	0.20	29	0.69	22.00	0.28	20	0.24	-57.45	5.01	-40.43
93	18.10	0.20	18	0.87	17.00	0.20	15	-13.60	-57.45	-18.85	-57.45
94	20.60	0.22	33	0.57	21.00	0.30	19	-1.67	-53.19	0.24	-36.17
95	22.00	0.28	19	1.02	22.00	0.28	20	5.01	-40.43	5.01	-40.43
96	20.90	0.22	27	0.68	19.00	0.20	19	-0.24	-53.19	-9.31	-57.45
97	22.00	0.28	25	0.78	22.00	0.28	20	5.01	-40.43	5.01	-40.43
98	18.20	0.20	22	0.76	18.00	0.20	17	-13.13	-57.45	-14.08	-57.45
99	17.90	0.20	21	0.79	17.00	0.20	17	-14.56	-57.45	-18.85	-57.45
100	19.80	0.24	23	0.78	18.00	0.20	18	-5.49	-48.94	-14.08	-57.45

Appendix Table B.1d Estimates and corresponding percentage bias of L_∞ and k obtained in the sub-sampling of 1000 length measurements using the two partitions for grouping the Red mullet data. The class numbers and the corresponding class widths for the data partition generated using the Birgé and Rozenholc algorithm are also reported.

Sample size = 1000 length measurements											
	Estimates							% Bias			
	Birgè and Rozenholc algorithm				1 cm			Birgè and Rozenholc algorithm		1 cm	
	L_∞ (cm)	k (year^{-1})	class number	class width (cm)	L_∞ (cm)	k (year^{-1})	class number	L_∞	k	L_∞	k
1	20.00	0.20	32	0.59	19.00	0.20	19	-4.53	-57.45	-9.31	-57.45
2	22.60	0.26	35	0.59	22.00	0.28	21	7.88	-44.68	5.01	-40.43
3	21.00	0.20	25	0.74	21.00	0.20	18	0.24	-57.45	0.24	-57.45
4	20.10	0.30	28	0.67	19.00	0.20	19	-4.06	-36.17	-9.31	-57.45
5	21.10	0.30	34	0.54	21.00	0.22	19	0.72	-36.17	0.24	-53.19
6	20.50	0.30	29	0.66	19.00	0.20	19	-2.15	-36.17	-9.31	-57.45
7	21.50	0.20	33	0.62	22.00	0.28	20	2.63	-57.45	5.01	-40.43
8	20.30	0.22	28	0.67	19.00	0.20	19	-3.10	-53.19	-9.31	-57.45
9	20.90	0.22	29	0.71	20.00	0.24	21	-0.24	-53.19	-4.53	-48.94
10	22.10	0.28	32	0.60	19.00	0.20	19	5.49	-40.43	-9.31	-57.45
11	19.70	0.20	41	0.47	20.00	0.24	19	-5.97	-57.45	-4.53	-48.94
12	20.60	0.22	37	0.53	22.00	0.28	20	-1.67	-53.19	5.01	-40.43
13	20.00	0.20	26	0.72	19.00	0.20	19	-4.53	-57.45	-9.31	-57.45
14	21.80	0.20	29	0.65	19.00	0.20	19	4.06	-57.45	-9.31	-57.45
15	21.00	0.22	33	0.58	19.00	0.20	19	0.24	-53.19	-9.31	-57.45
16	19.40	0.34	34	0.55	21.00	0.30	19	-7.40	-27.66	0.24	-36.17
17	19.70	0.32	28	0.66	19.00	0.20	19	-5.97	-31.91	-9.31	-57.45
18	19.60	0.24	36	0.51	19.00	0.20	18	-6.44	-48.94	-9.31	-57.45
19	20.00	0.20	32	0.58	21.00	0.22	19	-4.53	-57.45	0.24	-53.19
20	20.40	0.32	31	0.59	19.00	0.20	19	-2.63	-31.91	-9.31	-57.45
21	20.50	0.24	33	0.60	22.00	0.28	20	-2.15	-48.94	5.01	-40.43
22	20.10	0.20	37	0.52	19.00	0.20	19	-4.06	-57.45	-9.31	-57.45
23	20.60	0.28	29	0.64	19.00	0.20	19	-1.67	-40.43	-9.31	-57.45
24	19.40	0.32	33	0.55	19.00	0.20	18	-7.40	-31.91	-9.31	-57.45
25	20.90	0.22	31	0.61	20.00	0.24	19	-0.24	-53.19	-4.53	-48.94
26	18.80	0.20	29	0.61	18.00	0.20	18	-10.26	-57.45	-14.08	-57.45
27	20.00	0.24	24	0.78	20.00	0.24	19	-4.53	-48.94	-4.53	-48.94
28	21.30	0.20	38	0.55	22.00	0.28	21	1.67	-57.45	5.01	-40.43
29	21.30	0.20	30	0.70	22.00	0.28	21	1.67	-57.45	5.01	-40.43
30	21.00	0.20	43	0.47	21.00	0.26	20	0.24	-57.45	0.24	-44.68
31	20.40	0.30	29	0.66	19.00	0.20	19	-2.63	-36.17	-9.31	-57.45
32	19.80	0.34	25	0.76	19.00	0.20	19	-5.49	-27.66	-9.31	-57.45
33	20.80	0.28	28	0.70	21.00	0.26	20	-0.72	-40.43	0.24	-44.68
34	21.20	0.22	34	0.56	22.00	0.28	19	1.19	-53.19	5.01	-40.43
35	22.70	0.26	30	0.67	22.00	0.28	21	8.35	-44.68	5.01	-40.43
36	21.10	0.28	36	0.56	22.00	0.28	20	0.72	-40.43	5.01	-40.43
37	20.60	0.28	23	0.82	19.00	0.20	19	-1.67	-40.43	-9.31	-57.45
38	22.10	0.26	25	0.86	22.00	0.28	22	5.49	-44.68	5.01	-40.43
39	21.40	0.22	33	0.58	21.00	0.22	19	2.15	-53.19	0.24	-53.19
40	20.30	0.26	32	0.60	21.00	0.20	19	-3.10	-44.68	0.24	-57.45
41	20.30	0.24	30	0.64	20.00	0.24	20	-3.10	-48.94	-4.53	-48.94
42	22.60	0.20	42	0.47	21.00	0.20	20	7.88	-57.45	0.24	-57.45
43	18.60	0.24	23	0.75	20.00	0.24	18	-11.22	-48.94	-4.53	-48.94
44	21.10	0.20	33	0.57	19.00	0.20	19	0.72	-57.45	-9.31	-57.45
45	20.00	0.30	27	0.64	18.00	0.20	18	-4.53	-36.17	-14.08	-57.45
46	20.70	0.24	35	0.57	21.00	0.22	20	-1.19	-48.94	0.24	-53.19
47	21.90	0.20	37	0.54	22.00	0.28	20	4.53	-57.45	5.01	-40.43
48	19.60	0.20	33	0.56	21.00	0.22	18	-6.44	-57.45	0.24	-53.19
49	21.10	0.20	32	0.58	19.00	0.20	19	0.72	-57.45	-9.31	-57.45
50	21.40	0.22	47	0.42	19.00	0.20	19	2.15	-53.19	-9.31	-57.45
51	21.00	0.22	23	0.80	19.00	0.20	18	0.24	-53.19	-9.31	-57.45
52	19.30	0.24	33	0.55	19.00	0.20	18	-7.88	-48.94	-9.31	-57.45
53	21.10	0.20	34	0.54	19.00	0.20	19	0.72	-57.45	5.01	-57.45
54	21.00	0.22	38	0.54	22.00	0.28	21	0.24	-53.19	-4.53	-40.43
55	19.50	0.24	28	0.59	20.00	0.24	17	-6.92	-48.94	-9.31	-48.94
56	20.60	0.30	28	0.67	19.00	0.20	19	-1.67	-36.17	5.01	-57.45
57	19.90	0.32	31	0.62	22.00	0.28	19	-5.01	-31.91	-9.31	-40.43
58	20.80	0.22	39	0.49	19.00	0.20	19	-0.72	-53.19	0.24	-57.45
59	20.90	0.28	36	0.49	21.00	0.20	18	-0.24	-40.43	5.01	-57.45
60	20.00	0.20	28	0.69	22.00	0.28	19	-4.53	-57.45	0.24	-40.43
61	19.40	0.34	34	0.53	21.00	0.30	18	-7.40	-27.66	-9.31	-36.17
62	20.00	0.30	23	0.80	19.00	0.20	19	-4.53	-36.17	5.01	-57.45
63	21.00	0.30	23	0.86	22.00	0.28	19	0.24	-36.17	0.24	-40.43
64	19.50	0.24	41	0.44	21.00	0.30	18	-6.92	-48.94	0.24	-36.17
65	19.60	0.24	35	0.55	21.00	0.30	19	-6.44	-48.94	5.01	-36.17
66	22.80	0.22	40	0.51	22.00	0.28	21	8.83	-53.19	-18.85	-40.43
67	18.50	0.26	25	0.66	17.00	0.20	17	-11.69	-44.68	0.24	-57.45
68	20.10	0.22	32	0.61	21.00	0.20	19	-4.06	-53.19	5.01	-57.45
69	23.10	0.24	31	0.66	22.00	0.28	21	10.26	-48.94	0.24	-40.43
70	20.10	0.20	46	0.41	21.00	0.22	19	-4.06	-57.45	0.24	-53.19
71	19.30	0.24	25	0.70	21.00	0.20	18	-7.88	-48.94	5.01	-57.45
72	22.20	0.26	37	0.56	22.00	0.28	21	5.97	-44.68	0.24	-40.43
73	21.20	0.20	34	0.59	21.00	0.20	20	1.19	-57.45	-14.08	-57.45
74	20.60	0.22	29	0.63	18.00	0.20	18	-1.67	-53.19	-9.31	-57.45
75	19.30	0.20	33	0.56	19.00	0.20	19	-7.88	-57.45	-9.31	-57.45
76	20.40	0.20	30	0.63	19.00	0.20	19	-2.63	-57.45	-9.31	-57.45
77	19.00	0.20	31	0.58	19.00	0.20	18	-9.31	-57.45	-9.31	-57.45
78	22.00	0.20	37	0.53	19.00	0.20	19	5.01	-57.45	-14.08	-57.45
79	18.60	0.30	43	0.40	18.00	0.20	18	-11.22	-36.17	-9.31	-57.45
80	19.90	0.24	30	0.63	19.00	0.20	19	-5.01	-48.94	5.01	-57.45
81	23.40	0.26	36	0.58	22.00	0.28	21	11.69	-44.68	-14.08	-40.43
82	20.00	0.22	19	0.93	18.00	0.20	18	-4.53	-53.19	5.01	-57.45
83	20.80	0.22	36	0.55	22.00	0.28	20	-0.72	-53.19	-9.31	-40.43
84	19.60	0.32	22	0.84	19.00	0.20	19	-6.44	-31.91	-9.31	-57.45
85	21.10	0.22	33	0.58	19.00	0.20	19	0.72	-53.19	-9.31	-57.45
86	20.60	0.28	24	0.79	19.00	0.32	19	-1.67	-40.43	-14.08	-31.91
87	19.60	0.20	36	0.50	18.00	0.20	18	-6.44	-57.45	-9.31	-57.45
88	21.80	0.22	34	0.57	19.00	0.20	19	4.06	-53.19	-9.31	-57.45
89	19.80	0.22	44	0.42	19.00	0.20	19	-5.49	-53.19	-9.31	-57.45
90	20.10	0.24	32	0.60	19.00	0.20	19	-4.06	-48.94	-9.31	-57.45
91	20.10	0.20	45	0.42	19.00	0.20	19	-4.06	-57.45	-9.31	-57.45
92	22.30	0.20	28	0.68	19.00	0.20	19	6.44	-57.45	-14.08	-57.45
93	18.40	0.20	24	0.73	18.00	0.20	18	-12.17	-57.45	-14.08	-57.45
94	19.10	0.24	35	0.48	18.00	0.20	17	-8.83	-48.94	5.01	-57.45
95	21.90	0.20	37	0.54	22.00	0.28	20	4.53	-57.45	-9.31	-40.43
96	19.80	0.30	38	0.50	19.00	0.20	19	-5.49	-36.17	-9.31	-57.45
97	19.60	0.32	31	0.59	19.00	0.20	19	-6.44	-31.91	5.01	-57.45
98	20.90	0.28	33	0.62	22.00	0.28	20	-0.24	-40.43	-9.31	-40.43
99	21.60	0.28	28	0.68	19.00	0.20	19	3.10	-40.43	-9.31	-57.45
100	21.10	0.20	33	0.55	19.00	0.20	19	0.72	-57.45	-9.31	-57.45

Appendix Table B.2a Estimates and corresponding percentage bias of L_∞ and k obtained in the sub-sampling of 100 length measurements using the two partitions for grouping the European hake data. The class numbers and the corresponding class widths for the data partition generated using the Birgé and Rozenholc algorithm are also reported.

Sample size = 100 length measurements											
	Estimates							**% Bias**			
	Birgè and Rozenholc algorithm				2 cm			Birgè and Rozenholc algorithm		2 cm	
	L_∞ (cm)	k (year^{-1})	class number	class width (cm)	L_∞ (cm)	k (year^{-1})	class number	L_∞	k	L_∞	k
1	57.60	0.01	4	12.04	65.60	0.08	24	-8.89	-93.33	3.76	-46.67
2	57.60	0.01	3	16.26	105.60	0.07	25	-8.89	-93.33	67.04	-53.33
3	62.10	0.01	4	13.06	67.10	0.09	26	-1.77	-93.33	6.14	-40.00
4	54.00	0.01	3	14.78	81.00	0.05	22	-14.58	-93.33	28.12	-66.67
5	56.70	0.01	2	23.96	93.70	0.06	24	-10.31	-93.33	48.21	-60.00
6	56.70	0.01	3	15.89	111.70	0.07	24	-10.31	-93.33	76.68	-53.33
7	129.50	0.30	5	9.69	110.50	0.03	25	104.84	100.00	74.79	-80.00
8	59.40	0.01	2	24.93	98.40	0.06	25	-6.04	-93.33	55.65	-60.00
9	58.50	0.01	3	16.20	127.50	0.03	25	-7.47	-93.33	101.68	-80.00
10	63.00	0.01	3	17.69	108.00	0.05	27	-0.35	-93.33	70.83	-66.67
11	55.80	0.01	3	15.32	82.80	0.06	23	-11.74	-93.33	30.97	-60.00
12	64.80	0.01	3	19.30	110.80	0.03	29	2.50	-93.33	75.26	-80.00
13	59.40	0.01	5	10.05	84.40	0.06	25	-6.04	-93.33	33.50	-60.00
14	63.90	0.01	4	13.61	94.90	0.05	28	1.08	-93.33	50.11	-66.67
15	64.80	0.01	2	28.78	77.80	0.07	29	2.50	-93.33	23.06	-53.33
16	58.50	0.01	3	15.86	117.50	0.05	24	-7.47	-93.33	85.86	-66.67
17	59.40	0.01	3	17.09	64.40	0.07	26	-6.04	-93.33	1.87	-53.33
18	61.20	0.01	3	17.28	91.20	0.05	26	-3.20	-93.33	44.26	-66.67
19	54.90	0.01	4	11.15	57.90	0.11	22	-13.16	-93.33	-8.42	-26.67
20	58.50	0.01	3	16.32	126.50	0.06	25	-7.47	-93.33	100.09	-60.00
21	59.40	0.01	3	16.91	98.40	0.04	25	-6.04	-93.33	55.65	-73.33
22	60.30	0.01	3	17.25	89.30	0.09	26	-4.62	-93.33	41.25	-40.00
23	61.20	0.01	4	13.14	100.20	0.06	27	-3.20	-93.33	58.49	-60.00
24	60.30	0.01	2	25.18	65.30	0.08	25	-4.62	-93.33	3.29	-46.67
25	63.90	0.01	4	13.68	105.90	0.04	28	1.08	-93.33	67.51	-73.33
26	63.00	0.01	3	17.82	78.00	0.11	27	-0.35	-93.33	23.38	-26.67
27	60.30	0.01	3	16.93	98.30	0.05	26	-4.62	-93.33	55.49	-66.67
28	63.90	0.01	4	13.62	81.90	0.05	28	1.08	-93.33	29.55	-66.67
29	62.10	0.01	3	17.79	66.10	0.09	27	-1.77	-93.33	4.56	-40.00
30	61.20	0.01	3	17.48	71.20	0.07	26	-3.20	-93.33	12.62	-53.33
31	58.50	0.01	4	12.10	127.50	0.03	25	-7.47	-93.33	101.68	-80.00
32	55.80	0.01	3	15.16	78.80	0.10	23	-11.74	-93.33	24.64	-33.33
33	55.80	0.01	4	11.51	63.80	0.11	23	-11.74	-93.33	0.92	-26.67
34	59.40	0.01	3	16.69	69.40	0.09	25	-6.04	-93.33	9.78	-40.00
35	56.70	0.01	3	15.67	111.70	0.05	24	-10.31	-93.33	76.68	-66.67
36	59.40	0.01	3	16.99	121.40	0.03	26	-6.04	-93.33	92.03	-80.00
37	55.80	0.01	3	15.39	80.80	0.05	23	-11.74	-93.33	27.81	-66.67
38	58.50	0.01	3	16.70	106.50	0.04	25	-7.47	-93.33	68.46	-73.33
39	62.10	0.01	5	10.83	82.10	0.04	27	-1.77	-93.33	29.86	-73.33
40	60.30	0.01	3	17.03	72.30	0.08	26	-4.62	-93.33	14.36	-46.67
41	56.70	0.01	3	15.71	110.70	0.03	24	-10.31	-93.33	75.10	-80.00
42	59.40	0.01	3	16.41	100.40	0.06	25	-6.04	-93.33	58.81	-60.00
43	58.50	0.01	4	12.09	117.50	0.05	24	-7.47	-93.33	85.86	-66.67
44	123.80	0.30	5	9.06	115.80	0.04	23	95.82	100.00	83.17	-73.33
45	58.50	0.01	4	12.56	121.50	0.03	25	-7.47	-93.33	92.19	-80.00
46	62.10	0.01	4	13.35	66.10	0.04	27	-1.77	-93.33	4.56	-73.33
47	127.10	0.08	14	3.70	135.10	0.06	26	101.04	-46.67	113.70	-60.00
48	64.80	0.01	2	27.99	135.80	0.03	28	2.50	-93.33	114.81	-80.00
49	59.40	0.01	3	16.84	98.40	0.04	25	-6.04	-93.33	55.65	-73.33
50	55.80	0.01	3	15.47	110.80	0.03	23	-11.74	-93.33	75.26	-80.00
51	55.80	0.01	3	15.12	105.80	0.06	23	-11.74	-93.33	67.35	-60.00
52	58.50	0.01	3	16.05	100.50	0.05	24	-7.47	-93.33	58.97	-66.67
53	63.90	0.01	3	18.55	141.90	0.04	28	1.08	-93.33	124.45	-73.33
54	54.90	0.01	2	23.13	81.90	0.04	23	-13.16	-93.33	29.55	-73.33
55	58.50	0.01	3	16.48	126.50	0.04	25	-7.47	-93.33	100.09	-73.33
56	59.40	0.01	3	16.93	98.40	0.04	25	-6.04	-93.33	55.65	-73.33
57	63.00	0.01	2	27.61	77.00	0.05	28	-0.35	-93.33	21.80	-66.67
58	55.80	0.01	3	14.95	94.80	0.07	23	-11.74	-93.33	49.95	-53.33
59	59.40	0.01	2	25.65	100.40	0.03	26	-6.04	-93.33	58.81	-80.00
60	65.70	0.01	5	11.18	114.70	0.04	28	3.92	-93.33	81.43	-73.33
61	69.90	0.27	9	4.95	80.90	0.05	23	10.57	80.00	27.97	-66.67
62	123.80	0.30	10	4.63	110.80	0.03	23	95.82	100.00	75.26	-80.00
63	64.80	0.01	3	19.27	71.80	0.09	29	2.50	-93.33	13.57	-40.00
64	56.70	0.01	3	15.31	60.70	0.08	23	-10.31	-93.33	-3.99	-46.67
65	57.60	0.01	3	15.92	68.60	0.10	24	-8.89	-93.33	8.51	-33.33
66	61.20	0.01	3	17.41	61.20	0.07	26	-3.20	-93.33	-3.20	-53.33
67	57.60	0.01	4	12.00	76.60	0.04	24	-8.89	-93.33	21.16	-73.33
68	59.40	0.01	3	16.48	81.40	0.11	25	-6.04	-93.33	28.76	-26.67
69	56.70	0.01	3	15.87	63.70	0.10	24	-10.31	-93.33	0.76	-33.33
70	60.30	0.01	4	12.59	100.30	0.06	25	-4.62	-93.33	58.65	-60.00
71	59.40	0.01	3	17.35	115.40	0.03	26	-6.04	-93.33	82.54	-80.00
72	57.60	0.01	3	15.85	57.60	0.12	24	-8.89	-93.33	-8.89	-20.00
73	61.20	0.01	3	17.32	98.20	0.05	26	-3.20	-93.33	55.33	-66.67
74	61.20	0.01	4	12.77	66.20	0.11	26	-3.20	-93.33	4.71	-26.67
75	55.80	0.01	3	15.11	62.80	0.13	23	-11.74	-93.33	-0.66	-13.33
76	60.30	0.01	3	16.70	77.30	0.09	25	-4.62	-93.33	22.27	-40.00
77	75.60	0.15	15	3.83	115.60	0.04	29	19.58	0.00	82.85	-73.33
78	61.20	0.01	3	17.57	77.20	0.06	27	-3.20	-93.33	22.11	-60.00
79	59.40	0.01	2	24.40	126.40	0.05	25	-6.04	-93.33	99.94	-66.67
80	64.80	0.01	3	18.54	115.80	0.04	28	2.50	-93.33	83.17	-73.33
81	140.00	0.30	6	9.09	73.00	0.08	28	121.45	100.00	15.47	-46.67
82	59.40	0.01	3	16.56	126.40	0.05	25	-6.04	-93.33	99.94	-66.67
83	61.20	0.01	3	17.54	98.20	0.06	26	-3.20	-93.33	55.33	-60.00
84	62.10	0.01	4	13.03	71.10	0.07	27	-1.77	-93.33	12.46	-53.33
85	55.80	0.01	3	15.06	71.80	0.09	23	-11.74	-93.33	13.57	-40.00
86	59.40	0.01	3	16.94	121.40	0.03	26	-6.04	-93.33	92.03	-80.00
87	56.70	0.01	2	23.62	67.70	0.07	24	-10.31	-93.33	7.09	-53.33
88	57.60	0.01	3	16.07	65.60	0.08	24	-8.89	-93.33	3.76	-46.67
89	60.30	0.01	3	16.84	91.30	0.05	26	-4.62	-93.33	44.42	-66.67
90	59.40	0.01	3	16.68	69.40	0.09	25	-6.04	-93.33	9.78	-40.00
91	59.40	0.01	3	16.50	73.40	0.12	25	-6.04	-93.33	16.10	-20.00
92	63.00	0.01	4	13.23	86.00	0.09	27	-0.35	-93.33	36.03	-40.00
93	53.10	0.01	3	14.24	104.10	0.06	22	-16.01	-93.33	64.66	-60.00
94	52.20	0.01	2	20.95	104.20	0.06	21	-17.43	-93.33	64.82	-60.00
95	66.60	0.01	3	19.32	127.60	0.03	29	5.35	-93.33	101.83	-80.00
96	55.80	0.01	3	15.10	68.80	0.10	23	-11.74	-93.33	8.83	-33.33
97	59.40	0.01	3	16.44	61.40	0.06	25	-6.04	-93.33	-2.88	-60.00
98	59.40	0.01	4	12.36	69.40	0.09	25	-6.04	-93.33	9.78	-40.00
99	61.20	0.01	3	16.96	68.20	0.12	26	-3.20	-93.33	7.88	-20.00
100	58.50	0.01	3	16.12	69.50	0.09	25	-7.47	-93.33	9.93	-40.00

Appendix Table B.2b Estimates and corresponding percentage bias of L_∞ and k obtained in the sub-sampling of 200 length measurements using the two partitions for grouping the European hake data. The class numbers and the corresponding class widths for the data partition generated using the Birgé and Rozenholc algorithm are also reported.

	Sample size = 200 length measurements										
	Estimates							% Bias			
	Birgè and Rozenholc algorithm				2 cm			Birgè and Rozenholc algorithm		2 cm	
	L_∞ (cm)	*k (year^{-1})*	*class number*	*class width (cm)*	*L_∞ (cm)*	*k (year^{-1})*	*class number*	*L_∞*	*k*	*L_∞*	*k*
1	58.50	0.01	3	16.39	115.50	0.04	25	-7.47	-93.33	82.70	-73.33
2	63.00	0.01	3	17.98	69.00	0.09	27	-0.35	-93.33	9.14	-40.00
3	57.60	0.01	3	15.89	76.60	0.08	24	-8.89	-93.33	21.16	-46.67
4	62.10	0.01	3	17.95	77.10	0.06	27	-1.77	-93.33	21.96	-60.00
5	92.60	0.06	18	2.71	60.60	0.08	25	46.47	-60.00	-4.14	-46.67
6	62.40	0.30	11	4.50	98.40	0.08	25	-1.30	100.00	55.65	-46.67
7	61.20	0.01	3	17.88	135.20	0.04	27	-3.20	-93.33	113.86	-73.33
8	104.60	0.07	15	3.34	77.60	0.04	25	65.45	-53.33	22.75	-73.33
9	121.90	0.30	5	9.16	81.90	0.07	23	92.82	100.00	29.55	-53.33
10	63.90	0.01	4	13.74	110.90	0.03	28	1.08	-93.33	75.42	-80.00
11	72.20	0.23	13	4.01	104.20	0.06	26	14.20	53.33	64.82	-60.00
12	57.60	0.01	4	12.28	60.60	0.08	25	-8.89	-93.33	-4.14	-46.67
13	93.40	0.17	12	4.21	102.40	0.07	25	47.74	13.33	61.97	-53.33
14	58.50	0.01	3	16.21	120.50	0.08	25	-7.47	-93.33	90.60	-46.67
15	59.40	0.01	5	10.04	90.40	0.05	26	-6.04	-93.33	42.99	-66.67
16	92.10	0.12	18	3.01	77.10	0.06	27	45.68	-20.00	21.96	-60.00
17	114.60	0.29	10	4.82	127.60	0.03	24	81.27	93.33	101.83	-80.00
18	85.50	0.12	13	3.80	110.50	0.04	25	35.24	-20.00	74.79	-73.33
19	61.20	0.01	4	13.12	71.20	0.07	26	-3.20	-93.33	12.62	-53.33
20	98.50	0.18	9	5.49	69.50	0.09	25	55.81	20.00	9.93	-40.00
21	60.30	0.01	3	17.10	72.30	0.14	26	-4.62	-93.33	14.36	-6.67
22	62.10	0.01	5	10.72	71.10	0.07	27	-1.77	-93.33	12.46	-53.33
23	58.50	0.01	3	16.75	90.50	0.05	25	-7.47	-93.33	43.15	-66.67
24	92.50	0.06	18	2.78	110.50	0.05	25	46.31	-60.00	74.79	-66.67
25	61.20	0.01	4	13.28	135.20	0.04	27	-3.20	-93.33	113.86	-73.33
26	121.40	0.27	10	5.10	110.40	0.05	26	92.03	80.00	74.63	-66.67
27	70.10	0.11	18	3.01	66.10	0.06	27	10.88	-26.67	4.56	-60.00
28	91.90	0.13	11	5.03	80.90	0.05	28	45.37	-13.33	27.97	-66.67
29	87.10	0.20	11	4.86	122.10	0.05	27	37.77	33.33	93.14	-66.67
30	58.50	0.01	4	12.31	69.50	0.09	25	-7.47	-93.33	9.93	-40.00
31	63.90	0.01	3	18.47	93.90	0.04	28	1.08	-93.33	48.53	-73.33
32	137.90	0.03	23	2.45	81.90	0.04	28	118.13	-80.00	29.55	-73.33
33	97.70	0.16	11	4.31	93.70	0.08	24	54.54	6.67	48.21	-46.67
34	80.30	0.21	11	4.68	121.30	0.03	26	27.02	40.00	91.87	-80.00
35	57.60	0.01	3	16.10	119.60	0.06	24	-8.89	-93.33	89.18	-60.00
36	89.40	0.06	17	3.05	98.40	0.04	26	41.41	-60.00	55.65	-73.33
37	61.20	0.01	3	17.83	105.20	0.03	27	-3.20	-93.33	66.40	-80.00
38	107.20	0.15	11	4.74	131.20	0.06	27	69.57	0.00	107.53	-60.00
39	112.30	0.30	10	5.19	98.30	0.06	26	77.63	100.00	55.49	-60.00
40	112.50	0.14	11	4.45	69.50	0.09	25	77.95	-6.67	9.93	-40.00
41	59.40	0.01	4	12.82	110.40	0.05	26	-6.04	-93.33	74.63	-66.67
42	109.50	0.14	12	4.08	127.50	0.06	25	73.20	-6.67	101.68	-60.00
43	79.40	0.14	12	4.12	89.40	0.09	25	25.59	-6.67	41.41	-40.00
44	129.20	0.25	10	5.35	135.20	0.04	27	104.37	66.67	113.86	-73.33
45	61.20	0.01	3	17.56	77.20	0.06	27	-3.20	-93.33	22.11	-60.00
46	63.00	0.01	4	13.53	75.00	0.07	27	-0.35	-93.33	18.63	-53.33
47	59.40	0.01	4	12.42	91.40	0.07	25	-6.04	-93.33	44.57	-53.33
48	142.70	0.24	10	5.79	93.70	0.06	29	125.72	60.00	48.21	-60.00
49	90.20	0.08	17	3.20	89.20	0.06	27	42.68	-46.67	41.09	-60.00
50	59.40	0.01	3	16.87	98.40	0.04	25	-6.04	-93.33	55.65	-73.33
51	79.10	0.07	18	3.06	86.10	0.05	28	25.12	-53.33	36.19	-66.67
52	60.30	0.01	4	12.83	89.30	0.06	26	-4.62	-93.33	41.25	-60.00
53	92.10	0.18	11	4.88	66.10	0.06	27	45.68	20.00	4.56	-60.00
54	62.10	0.01	4	13.42	86.10	0.07	27	-1.77	-93.33	36.19	-53.33
55	101.30	0.16	11	4.69	89.30	0.09	26	60.23	6.67	41.25	-40.00
56	109.60	0.30	10	4.84	68.60	0.10	24	73.36	100.00	8.51	-33.33
57	60.30	0.01	3	17.26	64.30	0.12	26	-4.62	-93.33	1.71	-20.00
58	62.40	0.19	12	4.14	98.40	0.06	25	-1.30	26.67	55.65	-60.00
59	119.60	0.06	18	2.75	93.60	0.04	25	89.18	-60.00	48.05	-73.33
60	129.50	0.30	7	7.04	105.50	0.03	25	104.84	100.00	66.88	-80.00
61	91.20	0.12	21	2.51	77.20	0.10	27	44.26	-20.00	22.11	-33.33
62	133.10	0.30	10	5.31	66.10	0.06	27	110.53	100.00	4.56	-60.00
63	60.50	0.29	12	4.04	69.50	0.09	25	-4.30	93.33	9.93	-40.00
64	58.50	0.01	4	12.32	110.50	0.04	25	-7.47	-93.33	74.79	-73.33
65	85.20	0.13	12	4.34	71.20	0.07	26	34.77	-13.33	12.62	-53.33
66	80.10	0.07	14	3.98	72.10	0.07	28	26.70	-53.33	14.05	-53.33
67	133.30	0.29	7	7.44	110.30	0.05	26	110.85	93.33	74.47	-66.67
68	58.50	0.01	4	12.49	84.50	0.09	25	-7.47	-93.33	33.66	-40.00
69	80.50	0.27	7	7.03	71.50	0.13	25	27.33	80.00	13.10	-13.33
70	104.70	0.15	13	4.40	98.70	0.08	29	65.61	0.00	56.12	-46.67
71	92.50	0.12	19	2.62	110.50	0.05	25	46.31	-20.00	74.79	-66.67
72	64.80	0.01	3	18.97	93.80	0.03	29	2.50	-93.33	48.37	-80.00
73	58.50	0.01	3	16.53	110.50	0.05	25	-7.47	-93.33	74.79	-66.67
74	117.30	0.28	10	5.14	121.30	0.06	26	85.54	86.67	91.87	-60.00
75	70.00	0.24	11	3.93	82.00	0.08	22	10.72	60.00	29.71	-46.67
76	63.00	0.01	3	18.14	73.00	0.08	28	-0.35	-93.33	15.47	-46.67
77	102.90	0.18	9	6.25	67.90	0.07	28	62.76	20.00	7.40	-53.33
78	92.10	0.18	12	4.40	104.10	0.05	27	45.68	20.00	64.66	-66.67
79	62.10	0.01	3	17.77	86.10	0.07	27	-1.77	-93.33	36.19	-53.33
80	61.20	0.01	3	17.58	77.20	0.06	27	-3.20	-93.33	22.11	-60.00
81	63.00	0.01	3	18.25	73.00	0.08	28	-0.35	-93.33	15.47	-46.67
82	107.20	0.04	20	2.67	105.20	0.03	27	69.57	-73.33	66.40	-80.00
83	68.40	0.24	13	3.83	89.40	0.09	25	8.19	60.00	41.41	-40.00
84	80.50	0.23	9	5.52	121.50	0.03	25	27.33	53.33	92.19	-80.00
85	76.60	0.28	10	4.86	67.60	0.14	25	21.16	86.67	6.93	-6.67
86	72.10	0.15	13	4.09	77.10	0.06	27	14.05	0.00	21.96	-60.00
87	115.10	0.12	10	5.32	71.10	0.05	27	82.06	-20.00	12.46	-66.67
88	84.70	0.21	11	5.21	69.70	0.07	29	33.98	40.00	10.25	-53.33
89	61.20	0.01	3	17.33	61.20	0.07	26	-3.20	-93.33	-3.20	-53.33
90	57.60	0.01	4	12.12	63.60	0.08	24	-8.89	-93.33	0.60	-46.67
91	82.30	0.07	19	2.73	110.30	0.04	26	30.18	-53.33	74.47	-73.33
92	57.60	0.01	5	9.55	92.60	0.06	24	-8.89	-93.33	46.47	-60.00
93	60.30	0.01	3	17.13	89.30	0.09	26	-4.62	-93.33	41.25	-40.00
94	62.10	0.01	3	17.88	66.10	0.09	27	-1.77	-93.33	4.56	-40.00
95	123.50	0.26	10	4.94	90.50	0.05	25	95.35	73.33	43.15	-66.67
96	76.20	0.22	12	4.32	89.20	0.09	26	20.53	46.67	41.09	-40.00
97	63.20	0.12	18	3.00	89.20	0.06	27	-0.03	-20.00	41.09	-60.00
98	61.20	0.01	3	17.35	89.20	0.09	26	-3.20	-93.33	41.09	-40.00
99	92.90	0.11	15	3.64	81.90	0.10	28	46.95	-26.67	29.55	-33.33
100	136.00	0.30	10	5.45	86.00	0.07	27	115.12	100.00	36.03	-53.33

Appendix Table B.2c Estimates and corresponding percentage bias of L_∞ and k obtained in the sub-sampling of 500 length measurements using the two partitions for grouping the European hake data. The class numbers and the corresponding class widths for the data partition generated using the Birgé and Rozenholc algorithm are also reported.

	Sample size = 500 length measurements										
	Estimates							**% Bias**			
	Birgè and Rozenholc algorithm				2 cm			Birgè and Rozenholc algorithm		2 cm	
	L_∞ (cm)	*k (year^{-1})*	*class number*	*class width (cm)*	*L_∞ (cm)*	*k (year^{-1})*	*class number*	*L_∞*	*k*	*L_∞*	*k*
1	72.20	0.08	23	2.27	71.20	0.07	26	14.20	-46.67	12.62	-53.33
2	64.20	0.27	12	4.36	135.20	0.04	27	1.55	80.00	113.86	-73.33
3	88.20	0.13	19	2.78	61.20	0.14	26	39.51	-13.33	-3.20	-6.67
4	65.10	0.12	21	2.57	66.10	0.09	27	2.97	-20.00	4.56	-40.00
5	65.90	0.12	21	2.66	107.90	0.10	28	4.24	-20.00	70.67	-33.33
6	131.90	0.04	24	2.30	81.90	0.10	28	108.64	-73.33	29.55	-33.33
7	63.20	0.28	12	4.31	89.20	0.09	26	-0.03	86.67	41.09	-40.00
8	82.20	0.07	21	2.48	71.20	0.07	26	30.02	-53.33	12.62	-53.33
9	98.20	0.05	23	2.38	115.20	0.03	27	55.33	-66.67	82.22	-80.00
10	64.90	0.18	22	2.52	93.90	0.08	28	2.66	20.00	48.53	-46.67
11	135.70	0.04	31	1.87	93.70	0.06	29	114.65	-73.33	48.21	-60.00
12	136.00	0.03	31	1.74	86.00	0.07	27	115.12	-80.00	36.03	-53.33
13	73.30	0.08	16	3.30	110.30	0.04	26	15.94	-46.67	74.47	-73.33
14	77.60	0.06	26	1.88	60.60	0.10	25	22.75	-60.00	-4.14	-33.33
15	78.70	0.17	13	4.40	76.70	0.08	29	24.49	13.33	21.32	-46.67
16	78.00	0.13	25	2.24	89.00	0.08	28	23.38	-13.33	40.78	-46.67
17	93.80	0.08	28	2.06	77.80	0.07	29	48.37	-46.67	23.06	-53.33
18	139.90	0.24	10	5.49	94.90	0.05	28	121.29	60.00	50.11	-66.67
19	109.90	0.05	23	2.41	115.90	0.05	28	73.84	-66.67	83.33	-66.67
20	133.00	0.03	29	1.88	77.00	0.10	28	110.38	-80.00	21.80	-33.33
21	71.20	0.08	22	2.41	77.20	0.06	27	12.62	-46.67	22.11	-60.00
22	73.00	0.08	20	2.74	73.00	0.08	28	15.47	-46.67	15.47	-46.67
23	108.10	0.04	22	2.44	66.10	0.09	27	70.99	-73.33	4.56	-40.00
24	69.70	0.27	11	5.18	115.70	0.04	29	10.25	80.00	83.01	-73.33
25	135.80	0.04	21	2.70	115.80	0.04	28	114.81	-73.33	83.17	-73.33
26	75.80	0.24	11	5.14	93.80	0.06	29	19.90	60.00	48.37	-60.00
27	92.40	0.06	19	2.70	90.40	0.05	26	46.16	-60.00	42.99	-66.67
28	72.00	0.05	27	2.05	73.00	0.08	28	13.89	-66.67	15.47	-46.67
29	126.30	0.04	25	2.08	121.30	0.03	26	99.78	-73.33	91.87	-80.00
30	72.20	0.06	29	1.81	98.20	0.06	26	14.20	-60.00	55.33	-60.00
31	62.20	0.06	26	2.03	77.20	0.06	27	-1.61	-60.00	22.11	-60.00
32	111.80	0.05	28	2.04	93.80	0.06	29	76.84	-66.67	48.37	-60.00
33	84.90	0.09	18	3.11	81.90	0.07	28	34.29	-40.00	29.55	-53.33
34	65.00	0.09	19	2.90	73.00	0.08	28	2.82	-40.00	15.47	-46.67
35	70.10	0.06	25	2.17	89.10	0.06	28	10.88	-60.00	40.94	-60.00
36	138.00	0.04	26	2.12	77.00	0.06	28	118.29	-73.33	21.80	-60.00
37	68.40	0.26	11	4.60	98.40	0.06	25	8.19	73.33	55.65	-60.00
38	62.20	0.09	27	1.96	135.20	0.04	27	-1.61	-40.00	113.86	-73.33
39	84.90	0.05	26	2.14	93.90	0.04	28	34.29	-66.67	48.53	-73.33
40	136.10	0.03	23	2.35	77.10	0.06	27	115.28	-80.00	21.96	-60.00
41	81.80	0.07	21	2.70	93.80	0.06	29	29.39	-53.33	48.37	-60.00
42	113.00	0.10	19	2.85	86.00	0.07	27	78.74	-33.33	36.03	-53.33
43	91.10	0.08	19	2.89	66.10	0.09	27	44.10	-46.67	4.56	-40.00
44	132.00	0.04	21	2.60	77.00	0.06	28	108.79	-73.33	21.80	-60.00
45	86.90	0.05	23	2.43	93.90	0.04	28	37.46	-66.67	48.53	-73.33
46	63.30	0.09	22	2.34	110.30	0.05	26	0.13	-40.00	74.47	-66.67
47	104.40	0.05	22	2.34	110.40	0.05	26	65.14	-66.67	74.63	-66.67
48	109.20	0.05	19	2.79	135.20	0.04	27	72.73	-66.67	113.86	-73.33
49	74.20	0.06	21	2.51	77.20	0.10	27	17.37	-60.00	22.11	-33.33
50	111.70	0.04	21	2.71	68.70	0.10	29	76.68	-73.33	8.67	-33.33
51	76.30	0.25	13	3.92	89.30	0.09	26	20.69	66.67	41.25	-40.00
52	132.10	0.12	11	4.88	77.10	0.06	27	108.95	-20.00	21.96	-60.00
53	107.30	0.15	11	4.62	115.30	0.04	26	69.72	0.00	82.38	-73.33
54	90.00	0.06	27	2.02	81.00	0.06	27	42.36	-60.00	28.12	-60.00
55	73.10	0.08	18	2.99	66.10	0.09	27	15.63	-46.67	4.56	-40.00
56	125.00	0.04	26	2.12	77.00	0.06	28	97.72	-73.33	21.80	-60.00
57	112.30	0.05	27	1.93	110.30	0.05	26	77.63	-66.67	74.47	-66.67
58	64.80	0.28	12	4.69	115.80	0.05	28	2.50	86.67	83.17	-66.67
59	88.00	0.18	13	4.17	122.00	0.05	27	39.20	20.00	92.98	-66.67
60	69.10	0.17	16	3.43	89.10	0.06	28	9.30	13.33	40.94	-60.00
61	121.10	0.06	20	2.67	66.10	0.09	27	91.55	-60.00	4.56	-40.00
62	119.20	0.09	16	3.36	96.20	0.11	27	88.55	-40.00	52.17	-26.67
63	120.00	0.06	20	2.73	77.00	0.05	28	89.81	-60.00	21.80	-66.67
64	66.80	0.08	30	1.91	93.80	0.08	29	5.66	-46.67	48.37	-46.67
65	87.20	0.05	22	2.40	77.20	0.05	27	37.93	-66.67	22.11	-66.67
66	90.20	0.04	42	1.28	73.20	0.06	27	42.68	-73.33	15.79	-60.00
67	61.30	0.10	26	2.00	121.30	0.06	26	-3.04	-33.33	91.87	-60.00
68	58.50	0.08	35	1.43	90.50	0.05	25	-7.47	-46.67	43.15	-66.67
69	85.90	0.05	30	1.89	104.90	0.05	29	35.87	-66.67	65.93	-66.67
70	69.10	0.08	23	2.34	66.10	0.06	27	9.30	-46.67	4.56	-60.00
71	72.10	0.08	23	2.30	63.10	0.14	27	14.05	-46.67	-0.19	-6.67
72	63.10	0.12	24	2.23	66.10	0.09	27	-0.19	-20.00	4.56	-40.00
73	71.10	0.08	21	2.57	66.10	0.09	27	12.46	-46.67	4.56	-40.00
74	87.50	0.06	27	1.82	110.50	0.05	25	38.41	-60.00	74.79	-66.67
75	67.90	0.07	26	2.20	104.90	0.05	29	7.40	-53.33	65.93	-66.67
76	140.90	0.05	21	2.64	67.90	0.07	28	122.87	-66.67	7.40	-53.33
77	83.30	0.09	21	2.47	98.30	0.08	26	31.76	-40.00	55.49	-46.67
78	109.00	0.05	23	2.37	81.00	0.05	27	72.41	-66.67	28.12	-66.67
79	118.90	0.06	21	2.69	93.90	0.08	28	88.07	-60.00	48.53	-46.67
80	121.20	0.06	18	2.93	135.20	0.04	27	91.71	-60.00	113.86	-73.33
81	88.90	0.08	20	2.81	104.90	0.05	29	40.62	-46.67	65.93	-66.67
82	86.90	0.13	21	2.66	81.90	0.07	28	37.46	-13.33	29.55	-53.33
83	119.10	0.13	12	4.50	114.10	0.09	27	88.39	-13.33	80.48	-40.00
84	73.10	0.10	24	2.25	66.10	0.09	27	15.63	-33.33	4.56	-40.00
85	83.00	0.05	32	1.71	73.00	0.08	28	31.29	-66.67	15.47	-46.67
86	91.20	0.05	27	1.96	135.20	0.04	27	44.26	-66.67	113.86	-73.33
87	102.00	0.07	18	3.08	89.00	0.06	28	61.34	-53.33	40.78	-60.00
88	66.60	0.12	16	3.05	60.60	0.08	25	5.35	-20.00	-4.14	-46.67
89	78.40	0.10	18	2.77	89.40	0.12	25	24.01	-33.33	41.41	-20.00
90	91.90	0.18	12	4.56	105.90	0.08	28	45.37	20.00	67.51	-46.67
91	106.90	0.15	12	4.58	115.90	0.05	28	69.09	0.00	83.33	-66.67
92	71.10	0.08	23	2.34	66.10	0.09	27	12.46	-46.67	4.56	-40.00
93	80.90	0.07	21	2.68	93.90	0.04	28	27.97	-53.33	48.53	-73.33
94	119.90	0.06	17	3.36	88.90	0.08	29	89.66	-60.00	40.62	-46.67
95	91.80	0.08	21	2.70	93.80	0.06	29	45.21	-46.67	48.37	-60.00
96	69.20	0.08	21	2.52	135.20	0.04	27	9.46	-46.67	113.86	-73.33
97	78.00	0.09	22	2.52	89.00	0.08	28	23.38	-40.00	40.78	-46.67
98	93.20	0.06	30	1.75	135.20	0.04	27	47.42	-60.00	113.86	-73.33
99	117.90	0.06	18	3.15	85.90	0.05	29	86.49	-60.00	35.87	-66.67
100	108.90	0.05	20	2.80	93.90	0.08	28	72.26	-66.67	48.53	-46.67

Appendix Table B.2d Estimates and corresponding percentage bias of L_∞ and k obtained in the sub-sampling of 1000 length measurements using the two partitions for grouping the European hake data. The class numbers and the corresponding class widths for the data partition generated using the Birgé and Rozenholc algorithm are also reported.

	Sample size = 1000 length measurements										
	Estimates							**% Bias**			
	Birgè and Rozenholc algorithm				2 cm			Birgè and Rozenholc algorithm		2 cm	
	L_∞ (cm)	k (year^{-1})	class number	class width (cm)	L_∞ (cm)	k (year^{-1})	class number	L_∞	k	L_∞	k
1	136.80	0.05	33	1.76	78.80	0.07	29	116.39	-66.67	24.64	-53.33
2	71.10	0.11	32	1.69	79.10	0.07	27	12.46	-26.67	25.12	-53.33
3	115.80	0.05	37	1.53	77.80	0.10	28	83.17	-66.67	23.06	-33.33
4	98.30	0.06	25	2.07	86.30	0.05	26	55.49	-60.00	36.51	-66.67
5	93.80	0.04	39	1.45	86.80	0.05	29	48.37	-73.33	37.30	-66.67
6	77.80	0.07	30	1.93	133.80	0.04	29	23.06	-53.33	111.64	-73.33
7	93.80	0.08	37	1.52	119.80	0.06	29	48.37	-46.67	89.50	-60.00
8	67.90	0.07	23	2.42	139.90	0.05	28	7.40	-53.33	121.29	-66.67
9	93.90	0.08	33	1.69	92.90	0.06	28	48.53	-46.67	46.95	-60.00
10	104.70	0.04	30	1.94	119.70	0.06	30	65.61	-73.33	89.34	-60.00
11	93.70	0.06	30	1.93	127.70	0.04	29	48.21	-60.00	101.99	-73.33
12	104.70	0.04	36	1.63	67.70	0.07	30	65.61	-73.33	7.09	-53.33
13	71.10	0.11	21	2.55	103.10	0.07	27	12.46	-26.67	63.08	-53.33
14	77.80	0.07	31	1.88	78.80	0.07	29	23.06	-53.33	24.64	-53.33
15	89.00	0.06	38	1.47	109.00	0.04	28	40.78	-60.00	72.41	-73.33
16	66.10	0.09	19	2.85	87.10	0.13	27	4.56	-40.00	37.77	-13.33
17	81.90	0.07	27	2.08	66.90	0.09	28	29.55	-53.33	5.82	-40.00
18	67.80	0.07	38	1.50	138.80	0.03	29	7.24	-53.33	119.55	-80.00
19	81.90	0.07	26	2.17	126.90	0.04	28	29.55	-53.33	100.73	-73.33
20	85.90	0.05	33	1.71	115.90	0.03	29	35.87	-66.67	83.33	-80.00
21	73.00	0.08	41	1.34	82.00	0.07	28	15.47	-46.67	29.71	-53.33
22	66.10	0.09	29	1.86	134.10	0.04	27	4.56	-40.00	112.12	-73.33
23	81.80	0.08	35	1.61	110.80	0.04	28	29.39	-46.67	75.26	-73.33
24	115.80	0.05	13	4.33	79.80	0.21	28	83.17	-66.67	26.23	40.00
25	88.90	0.08	25	2.25	64.90	0.11	29	40.62	-46.67	2.66	-26.67
26	77.00	0.06	27	2.04	111.00	0.06	28	21.80	-60.00	75.58	-60.00
27	104.90	0.05	31	1.81	139.90	0.03	29	65.93	-66.67	121.29	-80.00
28	81.00	0.10	45	1.21	63.00	0.06	27	28.12	-33.33	-0.35	-60.00
29	81.90	0.07	45	1.25	118.90	0.03	28	29.55	-53.33	88.07	-80.00
30	89.00	0.06	29	1.95	138.00	0.05	28	40.78	-60.00	118.29	-66.67
31	77.00	0.10	24	2.29	89.00	0.08	28	21.80	-33.33	40.78	-46.67
32	81.90	0.07	45	1.25	112.90	0.03	28	29.55	-53.33	78.58	-80.00
33	89.10	0.12	35	1.56	103.10	0.04	28	40.94	-20.00	63.08	-73.33
34	73.00	0.08	27	2.06	95.00	0.06	28	15.47	-46.67	50.27	-60.00
35	93.80	0.06	41	1.38	129.80	0.04	29	48.37	-60.00	105.31	-73.33
36	81.90	0.07	32	1.74	64.90	0.09	28	29.55	-53.33	2.66	-40.00
37	93.70	0.06	25	2.32	78.70	0.07	29	48.21	-60.00	24.49	-53.33
38	77.00	0.10	33	1.66	65.00	0.18	28	21.80	-33.33	2.82	20.00
39	88.90	0.08	34	1.66	87.90	0.06	29	40.62	-46.67	39.04	-60.00
40	93.80	0.06	31	1.84	111.80	0.04	29	48.37	-60.00	76.84	-73.33
41	71.10	0.11	28	1.93	94.10	0.08	27	12.46	-26.67	48.85	-46.67
42	77.80	0.07	33	1.76	105.80	0.04	29	23.06	-53.33	67.35	-73.33
43	93.80	0.06	44	1.29	103.80	0.04	29	48.37	-60.00	64.19	-73.33
44	71.10	0.11	27	2.02	123.10	0.06	27	12.46	-26.67	94.72	-60.00
45	77.00	0.10	21	2.60	91.00	0.08	28	21.80	-33.33	43.94	-46.67
46	66.10	0.09	37	1.45	137.10	0.03	27	4.56	-40.00	116.86	-80.00
47	67.80	0.07	33	1.72	75.80	0.07	29	7.24	-53.33	19.90	-53.33
48	81.90	0.07	37	1.56	86.90	0.05	29	29.55	-53.33	37.46	-66.67
49	93.70	0.06	24	2.49	83.70	0.09	30	48.21	-60.00	32.39	-40.00
50	77.00	0.06	36	1.54	86.00	0.05	28	21.80	-60.00	36.03	-66.67
51	100.20	0.07	24	2.25	96.20	0.08	27	58.49	-53.33	52.17	-46.67
52	89.20	0.06	30	1.79	107.20	0.04	27	41.09	-60.00	69.57	-73.33
53	77.10	0.06	37	1.44	107.10	0.04	27	21.96	-60.00	69.41	-73.33
54	89.10	0.12	25	2.20	62.10	0.13	28	40.94	-20.00	-1.77	-13.33
55	73.00	0.08	33	1.66	133.00	0.04	28	15.47	-46.67	110.38	-73.33
56	71.10	0.11	32	1.70	107.10	0.10	27	12.46	-26.67	69.41	-33.33
57	104.90	0.05	28	2.02	107.90	0.05	29	65.93	-66.67	70.67	-66.67
58	93.80	0.06	44	1.29	81.80	0.07	29	48.37	-60.00	29.39	-53.33
59	89.00	0.06	25	2.24	94.00	0.06	28	40.78	-60.00	48.69	-60.00
60	143.50	0.03	30	2.01	111.50	0.04	30	126.99	-80.00	76.37	-73.33
61	66.10	0.09	30	1.82	92.10	0.08	27	4.56	-40.00	45.68	-46.67
62	89.00	0.08	18	3.13	79.00	0.14	28	40.78	-46.67	24.96	-6.67
63	81.90	0.07	38	1.47	107.90	0.04	28	29.55	-53.33	70.67	-73.33
64	71.10	0.11	29	2.21	113.10	0.06	32	12.46	-26.67	78.90	-60.00
65	89.10	0.06	26	2.12	85.10	0.09	28	40.94	-60.00	34.61	-40.00
66	81.90	0.07	30	1.87	89.90	0.05	28	29.55	-53.33	42.20	-66.67
67	135.20	0.04	31	1.72	81.20	0.07	27	113.86	-73.33	28.44	-53.33
68	105.60	0.07	26	2.27	77.60	0.14	30	67.04	-53.33	22.75	-6.67
69	81.90	0.07	25	2.22	79.90	0.09	28	29.55	-53.33	26.38	-40.00
70	89.00	0.08	33	1.70	90.00	0.06	28	40.78	-46.67	42.36	-60.00
71	66.10	0.09	42	1.29	62.10	0.06	27	4.56	-40.00	-1.77	-60.00
72	93.80	0.08	37	1.56	127.80	0.04	29	48.37	-46.67	102.15	-73.33
73	81.90	0.07	25	2.24	116.90	0.06	28	29.55	-53.33	84.91	-60.00
74	136.80	0.05	36	1.59	135.80	0.03	29	116.39	-66.67	114.81	-80.00
75	77.00	0.10	20	2.76	64.00	0.18	28	21.80	-33.33	1.23	20.00
76	94.90	0.05	26	2.13	129.90	0.04	28	50.11	-66.67	105.47	-73.33
77	81.90	0.07	31	1.81	97.90	0.07	28	29.55	-53.33	54.86	-53.33
78	89.10	0.08	27	2.03	93.10	0.06	28	40.94	-46.67	47.26	-60.00
79	104.80	0.04	37	1.55	133.80	0.03	29	65.77	-73.33	111.64	-80.00
80	81.90	0.07	31	1.82	108.90	0.04	28	29.55	-53.33	72.26	-73.33
81	89.10	0.06	27	2.05	92.10	0.06	28	40.94	-60.00	45.68	-60.00
82	105.60	0.07	49	1.21	119.60	0.03	30	67.04	-53.33	89.18	-80.00
83	73.00	0.08	33	1.67	104.00	0.07	28	15.47	-46.67	64.50	-53.33
84	77.00	0.10	28	1.96	112.00	0.06	28	21.80	-33.33	77.16	-60.00
85	77.00	0.10	28	1.97	106.00	0.07	28	21.80	-33.33	67.67	-53.33
86	89.10	0.06	22	2.46	68.10	0.08	28	40.94	-60.00	7.72	-46.67
87	66.10	0.09	35	1.53	107.10	0.05	27	4.56	-40.00	69.41	-66.67
88	127.10	0.06	31	1.70	89.10	0.04	27	101.04	-60.00	40.94	-73.33
89	73.00	0.08	39	1.42	138.00	0.03	28	15.47	-46.67	118.29	-80.00
90	81.90	0.07	22	2.55	70.90	0.08	28	29.55	-53.33	12.15	-46.67
91	67.80	0.07	29	1.98	77.80	0.06	29	7.24	-53.33	23.06	-60.00
92	67.80	0.07	34	1.69	78.80	0.07	29	7.24	-53.33	24.64	-53.33
93	104.80	0.04	33	1.75	138.80	0.03	29	65.77	-73.33	119.55	-80.00
94	73.00	0.08	36	1.55	86.00	0.05	28	15.47	-46.67	36.03	-66.67
95	77.10	0.06	35	1.54	91.10	0.06	27	21.96	-60.00	44.10	-60.00
96	71.10	0.11	34	1.60	130.10	0.04	27	12.46	-26.67	105.79	-73.33
97	77.10	0.06	31	1.74	66.10	0.07	27	21.96	-60.00	4.56	-53.33
98	93.90	0.08	16	3.63	114.90	0.09	29	48.53	-46.67	81.75	-40.00
99	110.30	0.04	35	1.78	143.30	0.03	31	74.47	-73.33	126.67	-80.00
100	88.90	0.08	32	1.79	105.90	0.04	29	40.62	-46.67	67.51	-73.33

Appendix Table B.3a Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 100 length measurements using the two partitions for grouping the Red mullet data.

	Sample size = 100 length measurements														
	Estimates														
	Birgè and Rozenholc algorithm														
	mean 1 (cm)	*mean 2 (cm)*	*mean 3 (cm)*	*mean 4 (cm)*	*mean 5 (cm)*	*mean 6 (cm)*	*mean 7 (cm)*	*SD 1 (cm)*	*SD 2 (cm)*	*SD 3 (cm)*	*SD 4 (cm)*	*SD 5 (cm)*	*SD 6 (cm)*	*SD 7 (cm)*
1	13.07	/	/	/	/	/	/	1.63	/	/	/	/	/	/
2	14.75	/	/	/	/	/	/	3.09	/	/	/	/	/	/
3	10.98	14.66	/	/	/	/	/	1.50	1.57	/	/	/	/	/
4	12.93	/	/	/	/	/	/	3.39	/	/	/	/	/	/
5	12.61	/	/	/	/	/	/	2.52	/	/	/	/	/	/
6	13.14	/	/	/	/	/	/	4.06	/	/	/	/	/	/
7	11.60	/	/	/	/	/	/	2.75	/	/	/	/	/	/
8	15.29	/	/	/	/	/	/	3.18	/	/	/	/	/	/
9	12.26	/	/	/	/	/	/	2.57	/	/	/	/	/	/
10	12.61	/	/	/	/	/	/	2.03	/	/	/	/	/	/
11	12.64	/	/	/	/	/	/	2.82	/	/	/	/	/	/
12	12.07	13.82	/	/	/	/	/	2.27	1.93	/	/	/	/	/
13	11.84	/	/	/	/	/	/	2.62	/	/	/	/	/	/
14	13.68	/	/	/	/	/	/	3.23	/	/	/	/	/	/
15	12.71	/	/	/	/	/	/	2.99	/	/	/	/	/	/
16	11.30	/	/	/	/	/	/	1.03	/	/	/	/	/	/
17	12.07	/	/	/	/	/	/	3.26	/	/	/	/	/	/
18	12.24	/	/	/	/	/	/	3.80	/	/	/	/	/	/
19	12.59	/	/	/	/	/	/	2.13	/	/	/	/	/	/
20	13.80	/	/	/	/	/	/	2.81	/	/	/	/	/	/
21	15.32	/	/	/	/	/	/	1.99	/	/	/	/	/	/
22	13.50	/	/	/	/	/	/	2.54	/	/	/	/	/	/
23	13.19	/	/	/	/	/	/	3.92	/	/	/	/	/	/
24	12.77	/	/	/	/	/	/	2.65	/	/	/	/	/	/
25	11.42	14.94	16.42	/	/	/	/	1.19	2.40	2.24	/	/	/	/
26	13.09	/	/	/	/	/	/	2.72	/	/	/	/	/	/
27	13.05	15.60	/	/	/	/	/	2.12	3.09	/	/	/	/	/
28	11.20	/	/	/	/	/	/	3.02	/	/	/	/	/	/
29	15.42	/	/	/	/	/	/	2.05	/	/	/	/	/	/
30	12.57	10.80	/	/	/	/	/	2.36	5.17	/	/	/	/	/
31	12.72	/	/	/	/	/	/	3.24	/	/	/	/	/	/
32	10.57	/	/	/	/	/	/	5.29	/	/	/	/	/	/
33	/	/	/	/	/	/	/	/	/	/	/	/	/	/
34	13.12	/	/	/	/	/	/	3.61	/	/	/	/	/	/
35	11.46	/	/	/	/	/	/	2.72	/	/	/	/	/	/
36	13.38	/	/	/	/	/	/	1.87	/	/	/	/	/	/
37	11.11	/	/	/	/	/	/	1.23	/	/	/	/	/	/
38	15.30	/	/	/	/	/	/	2.09	/	/	/	/	/	/
39	12.99	14.26	/	/	/	/	/	2.01	3.08	/	/	/	/	/
40	12.21	/	/	/	/	/	/	3.91	/	/	/	/	/	/
41	12.36	/	/	/	/	/	/	2.63	/	/	/	/	/	/
42	11.76	16.55	/	/	/	/	/	0.91	1.31	/	/	/	/	/
43	12.74	/	/	/	/	/	/	3.67	/	/	/	/	/	/
44	11.72	/	/	/	/	/	/	1.53	/	/	/	/	/	/
45	12.68	/	/	/	/	/	/	2.90	/	/	/	/	/	/
46	13.56	/	/	/	/	/	/	3.43	/	/	/	/	/	/
47	/	/	/	/	/	/	/	/	/	/	/	/	/	/
48	/	/	/	/	/	/	/	/	/	/	/	/	/	/
49	13.65	/	/	/	/	/	/	3.09	/	/	/	/	/	/
50	13.28	13.67	/	/	/	/	/	2.36	3.83	/	/	/	/	/
51	12.67	/	/	/	/	/	/	2.67	/	/	/	/	/	/
52	12.84	/	/	/	/	/	/	2.34	/	/	/	/	/	/
53	13.16	/	/	/	/	/	/	2.97	/	/	/	/	/	/
54	14.01	14.57	/	/	/	/	/	2.80	3.83	/	/	/	/	/
55	12.82	/	/	/	/	/	/	1.93	/	/	/	/	/	/
56	16.30	/	/	/	/	/	/	3.18	/	/	/	/	/	/
57	10.32	15.03	15.35	/	/	/	/	1.11	1.54	1.34	/	/	/	/
58	12.46	16.73	/	/	/	/	/	1.57	1.09	/	/	/	/	/
59	11.70	/	/	/	/	/	/	1.75	/	/	/	/	/	/
60	7.18	11.94	15.75	/	/	/	/	0.85	1.14	1.00	/	/	/	/
61	13.83	/	/	/	/	/	/	3.22	/	/	/	/	/	/
62	12.01	/	/	/	/	/	/	1.74	/	/	/	/	/	/
63	15.22	/	/	/	/	/	/	1.02	/	/	/	/	/	/
64	11.30	/	/	/	/	/	/	1.29	/	/	/	/	/	/
65	14.78	/	/	/	/	/	/	1.92	/	/	/	/	/	/
66	/	/	/	/	/	/	/	/	/	/	/	/	/	/
67	12.35	/	/	/	/	/	/	2.17	/	/	/	/	/	/
68	11.31	11.50	15.62	/	/	/	/	2.48	1.55	1.71	/	/	/	/
69	12.54	12.87	/	/	/	/	/	2.31	3.54	/	/	/	/	/
70	12.07	13.79	/	/	/	/	/	2.06	2.22	/	/	/	/	/
71	11.80	16.02	19.42	/	/	/	/	0.80	1.01	0.96	/	/	/	/
72	12.66	/	/	/	/	/	/	3.02	/	/	/	/	/	/
73	11.96	15.70	/	/	/	/	/	1.03	1.11	/	/	/	/	/
74	13.06	/	/	/	/	/	/	2.68	/	/	/	/	/	/
75	13.47	15.08	/	/	/	/	/	2.51	2.58	/	/	/	/	/
76	13.53	/	/	/	/	/	/	2.74	/	/	/	/	/	/
77	15.33	/	/	/	/	/	/	2.27	/	/	/	/	/	/
78	11.56	/	/	/	/	/	/	1.49	/	/	/	/	/	/
79	12.98	/	/	/	/	/	/	1.86	/	/	/	/	/	/
80	13.26	/	/	/	/	/	/	3.09	/	/	/	/	/	/
81	12.97	/	/	/	/	/	/	2.14	/	/	/	/	/	/
82	14.01	/	/	/	/	/	/	2.48	/	/	/	/	/	/
83	12.92	/	/	/	/	/	/	2.27	/	/	/	/	/	/
84	12.60	/	/	/	/	/	/	2.56	/	/	/	/	/	/
85	6.99	14.80	/	/	/	/	/	0.80	1.13	/	/	/	/	/
86	13.44	/	/	/	/	/	/	3.38	/	/	/	/	/	/
87	12.87	/	/	/	/	/	/	2.65	/	/	/	/	/	/
88	12.47	/	/	/	/	/	/	2.91	/	/	/	/	/	/
89	13.59	/	/	/	/	/	/	2.49	/	/	/	/	/	/
90	/	/	/	/	/	/	/	/	/	/	/	/	/	/
91	12.75	/	/	/	/	/	/	3.09	/	/	/	/	/	/
92	13.57	/	/	/	/	/	/	2.80	/	/	/	/	/	/
93	12.98	13.79	/	/	/	/	/	2.26	2.91	/	/	/	/	/
94	12.06	12.42	/	/	/	/	/	2.02	3.38	/	/	/	/	/
95	13.51	/	/	/	/	/	/	3.18	/	/	/	/	/	/
96	/	/	/	/	/	/	/	/	/	/	/	/	/	/
97	12.53	/	/	/	/	/	/	2.56	/	/	/	/	/	/
98	11.10	15.48	/	/	/	/	/	1.47	2.51	/	/	/	/	/
99	7.39	12.16	14.38	/	/	/	/	0.81	1.23	1.76	/	/	/	/
100	7.16	12.16	19.53	/	/	/	/	0.63	2.10	1.26	/	/	/	/

Appendix Table B.3b Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 100 length measurements using the two partitions for grouping the Red mullet data.

	Sample size = 100 length measurements													
	Estimates													
	1 cm													
	mean 1 (cm)	*mean 2 (cm)*	*mean 3 (cm)*	*mean 4 (cm)*	*mean 5 (cm)*	*mean 6 (cm)*	*mean 7 (cm)*	*SD 1 (cm)*	*SD 2 (cm)*	*SD 3 (cm)*	*SD 4 (cm)*	*SD 5 (cm)*	*SD 6 (cm)*	*SD 7 (cm)*
1	7.61	8.22	11.75	12.05	/	/	/	0.16	0.08	0.11	0.12	/	/	/
2	7.47	7.95	/	/	/	/	/	0.32	0.13	/	/	/	/	/
3	8.23	/	/	/	/	/	/	0.13	/	/	/	/	/	/
4	7.40	7.91	/	/	/	/	/	0.12	0.06	/	/	/	/	/
5	7.11	/	/	/	/	/	/	0.06	/	/	/	/	/	/
6	/	/	/	/	/	/	/	/	/	/	/	/	/	/
7	7.85	/	/	/	/	/	/	0.29	/	/	/	/	/	/
8	8.10	8.42	12.65	/	/	/	/	0.06	0.08	0.12	/	/	/	/
9	6.90	7.37	11.70	/	/	/	/	0.08	0.12	0.15	/	/	/	/
10	6.99	8.27	/	/	/	/	/	0.13	0.13	/	/	/	/	/
11	6.60	11.45	12.40	/	/	/	/	0.07	0.11	0.15	/	/	/	/
12	6.70	7.30	11.95	/	/	/	/	0.07	0.06	0.10	/	/	/	/
13	6.90	7.23	11.40	/	/	/	/	0.12	0.09	0.08	/	/	/	/
14	7.95	11.85	/	/	/	/	/	0.13	0.17	/	/	/	/	/
15	6.55	6.96	7.47	/	/	/	/	0.10	0.14	0.13	/	/	/	/
16	7.92	12.45	/	/	/	/	/	0.06	0.09	/	/	/	/	/
17	6.95	7.55	7.95	8.25	/	/	/	0.11	0.15	0.09	0.09	/	/	/
18	11.49	/	/	/	/	/	/	0.11	/	/	/	/	/	/
19	7.20	7.85	11.44	12.31	13.10	/	/	0.11	0.12	0.17	0.19	0.19	/	/
20	7.22	7.55	12.14	/	/	/	/	0.11	0.09	0.17	/	/	/	/
21	7.13	7.60	11.88	/	/	/	/	0.13	0.12	0.17	/	/	/	/
22	7.57	/	/	/	/	/	/	0.32	/	/	/	/	/	/
23	7.10	7.72	8.12	/	/	/	/	0.25	0.11	0.11	/	/	/	/
24	7.70	8.59	/	/	/	/	/	0.22	0.19	/	/	/	/	/
25	7.59	8.25	11.35	14.95	/	/	/	0.14	0.11	0.11	0.12	/	/	/
26	7.22	7.75	/	/	/	/	/	0.14	0.13	/	/	/	/	/
27	7.65	/	/	/	/	/	/	0.13	/	/	/	/	/	/
28	7.95	/	/	/	/	/	/	0.13	/	/	/	/	/	/
29	7.25	7.60	11.50	12.40	/	/	/	0.13	0.06	0.08	0.08	/	/	/
30	7.48	7.85	8.29	11.30	11.92	13.29	/	0.11	0.08	0.19	0.19	0.16	0.19	/
31	7.02	7.38	8.45	/	/	/	/	0.11	0.12	0.12	/	/	/	/
32	7.36	7.70	/	/	/	/	/	0.14	0.07	/	/	/	/	/
33	7.43	/	/	/	/	/	/	0.12	/	/	/	/	/	/
34	7.40	7.75	8.28	13.10	/	/	/	0.12	0.11	0.14	0.15	/	/	/
35	7.11	7.42	8.13	8.50	11.77	/	/	0.11	0.07	0.14	0.08	0.13	/	/
36	7.30	7.65	/	/	/	/	/	0.12	0.08	/	/	/	/	/
37	7.10	7.49	11.20	/	/	/	/	0.12	0.10	0.19	/	/	/	/
38	7.50	8.80	11.85	/	/	/	/	0.19	0.08	0.11	/	/	/	/
39	7.28	7.66	8.23	11.89	13.15	/	/	0.10	0.21	0.13	0.13	0.12	/	/
40	7.59	8.30	/	/	/	/	/	0.17	0.07	/	/	/	/	/
41	7.63	8.05	12.26	/	/	/	/	0.21	0.08	0.17	/	/	/	/
42	6.87	7.62	11.72	12.30	/	/	/	0.15	0.10	0.07	0.08	/	/	/
43	7.59	8.01	/	/	/	/	/	0.13	0.25	/	/	/	/	/
44	7.46	12.13	/	/	/	/	/	0.17	0.18	/	/	/	/	/
45	6.74	7.33	12.20	/	/	/	/	0.17	0.10	0.08	/	/	/	/
46	6.82	7.59	8.00	/	/	/	/	0.16	0.13	0.16	/	/	/	/
47	8.10	/	/	/	/	/	/	0.12	/	/	/	/	/	/
48	7.18	/	/	/	/	/	/	0.12	/	/	/	/	/	/
49	6.87	7.32	/	/	/	/	/	0.13	0.13	/	/	/	/	/
50	7.08	7.64	8.10	12.40	/	/	/	0.17	0.20	0.06	0.08	/	/	/
51	8.30	11.35	12.60	/	/	/	/	0.08	0.17	0.08	/	/	/	/
52	7.44	8.27	12.65	/	/	/	/	0.17	0.14	0.12	/	/	/	/
53	6.79	8.05	8.49	/	/	/	/	0.13	0.09	0.19	/	/	/	/
54	7.17	7.45	/	/	/	/	/	0.10	0.12	/	/	/	/	/
55	7.38	8.70	/	/	/	/	/	0.13	0.19	/	/	/	/	/
56	7.79	11.60	17.69	/	/	/	/	0.10	0.08	0.19	/	/	/	/
57	7.43	7.79	11.70	/	/	/	/	0.08	0.12	0.07	/	/	/	/
58	6.82	/	/	/	/	/	/	0.08	/	/	/	/	/	/
59	7.48	7.71	8.03	/	/	/	/	0.15	0.10	0.16	/	/	/	/
60	7.42	7.93	15.32	/	/	/	/	0.15	0.13	0.07	/	/	/	/
61	7.63	8.15	/	/	/	/	/	0.09	0.11	/	/	/	/	/
62	7.57	11.53	12.50	/	/	/	/	0.17	0.13	0.19	/	/	/	/
63	7.30	7.80	12.60	/	/	/	/	0.12	0.08	0.08	/	/	/	/
64	7.08	/	/	/	/	/	/	0.11	/	/	/	/	/	/
65	7.25	7.55	7.89	11.50	12.15	/	/	0.10	0.08	0.10	0.08	0.10	/	/
66	7.06	7.70	8.22	/	/	/	/	0.18	0.19	0.08	/	/	/	/
67	7.95	/	/	/	/	/	/	0.09	/	/	/	/	/	/
68	7.20	8.05	/	/	/	/	/	0.19	0.11	/	/	/	/	/
69	6.91	7.80	8.50	/	/	/	/	0.10	0.12	0.08	/	/	/	/
70	7.04	7.55	/	/	/	/	/	0.10	0.10	/	/	/	/	/
71	6.75	7.32	11.75	/	/	/	/	0.17	0.14	0.12	/	/	/	/
72	7.43	/	/	/	/	/	/	0.08	/	/	/	/	/	/
73	7.34	7.66	8.11	/	/	/	/	0.13	0.18	0.13	/	/	/	/
74	7.42	7.97	12.75	/	/	/	/	0.15	0.12	0.12	/	/	/	/
75	7.31	7.91	14.70	/	/	/	/	0.16	0.13	0.19	/	/	/	/
76	7.35	7.95	/	/	/	/	/	0.10	0.18	/	/	/	/	/
77	7.31	7.86	/	/	/	/	/	0.11	0.15	/	/	/	/	/
78	7.10	7.54	8.01	12.85	/	/	/	0.06	0.17	0.11	0.09	/	/	/
79	7.05	8.30	12.70	/	/	/	/	0.12	0.08	0.15	/	/	/	/
80	7.18	/	/	/	/	/	/	0.11	/	/	/	/	/	/
81	6.90	7.42	12.80	/	/	/	/	0.05	0.08	0.07	/	/	/	/
82	6.88	8.25	8.50	/	/	/	/	0.17	0.09	0.07	/	/	/	/
83	7.35	7.89	/	/	/	/	/	0.10	0.17	/	/	/	/	/
84	7.58	8.19	12.05	/	/	/	/	0.09	0.10	0.12	/	/	/	/
85	6.96	7.72	8.50	11.25	11.80	/	/	0.17	0.23	0.08	0.12	0.08	/	/
86	6.96	7.91	12.12	/	/	/	/	0.17	0.13	0.08	/	/	/	/
87	7.47	8.15	11.58	/	/	/	/	0.09	0.08	0.14	/	/	/	/
88	7.05	7.51	/	/	/	/	/	0.11	0.20	/	/	/	/	/
89	7.33	7.85	11.62	15.60	/	/	/	0.08	0.13	0.08	0.08	/	/	/
90	7.52	7.91	11.95	13.50	/	/	/	0.11	0.11	0.11	0.08	/	/	/
91	8.53	12.35	12.90	/	/	/	/	0.18	0.12	0.08	/	/	/	/
92	6.95	7.28	12.29	/	/	/	/	0.12	0.11	0.13	/	/	/	/
93	7.46	8.11	12.70	/	/	/	/	0.26	0.11	0.06	/	/	/	/
94	7.31	7.87	/	/	/	/	/	0.11	0.11	/	/	/	/	/
95	6.95	7.38	7.90	12.85	15.60	/	/	0.11	0.11	0.12	0.17	0.08	/	/
96	13.75	/	/	/	/	/	/	0.11	/	/	/	/	/	/
97	7.23	7.57	12.40	/	/	/	/	0.09	0.13	0.16	/	/	/	/
98	7.38	/	/	/	/	/	/	0.11	/	/	/	/	/	/
99	7.95	12.13	/	/	/	/	/	0.09	0.13	/	/	/	/	/
100	7.65	7.91	/	/	/	/	/	0.08	0.06	/	/	/	/	/

Appendix Table B.3c Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 100 length measurements using the two partitions for grouping the Red mullet data.

	Sample size = 100 length measurements													
	% Bias													
	Birgè and Rozenholc algorithm													
	mean 1	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*mean 7*	*SD 1*	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*	*SD 7*
1	71.92	/	/	/	/	/	/	150.63	/	/	/	/	/	/
2	94.06	/	/	/	/	/	/	375.09	/	/	/	/	/	/
3	44.42	20.94	/	/	/	/	/	131.26	73.84	/	/	/	/	/
4	70.17	/	/	/	/	/	/	420.53	/	/	/	/	/	/
5	65.86	/	/	/	/	/	/	287.22	/	/	/	/	/	/
6	72.87	/	/	/	/	/	/	523.40	/	/	/	/	/	/
7	52.68	/	/	/	/	/	/	322.88	/	/	/	/	/	/
8	101.19	/	/	/	/	/	/	389.02	/	/	/	/	/	/
9	61.28	/	/	/	/	/	/	294.84	/	/	/	/	/	/
10	65.98	/	/	/	/	/	/	212.28	/	/	/	/	/	/
11	66.25	/	/	/	/	/	/	333.75	/	/	/	/	/	/
12	58.87	14.04	/	/	/	/	/	248.41	114.25	/	/	/	/	/
13	55.81	/	/	/	/	/	/	303.37	/	/	/	/	/	/
14	80.03	/	/	/	/	/	/	396.93	/	/	/	/	/	/
15	67.21	/	/	/	/	/	/	358.82	/	/	/	/	/	/
16	48.72	/	/	/	/	/	/	58.45	/	/	/	/	/	/
17	58.75	/	/	/	/	/	/	401.29	/	/	/	/	/	/
18	61.01	/	/	/	/	/	/	483.76	/	/	/	/	/	/
19	65.62	/	/	/	/	/	/	226.61	/	/	/	/	/	/
20	81.53	/	/	/	/	/	/	331.79	/	/	/	/	/	/
21	101.54	/	/	/	/	/	/	205.86	/	/	/	/	/	/
22	77.69	/	/	/	/	/	/	290.59	/	/	/	/	/	/
23	73.62	/	/	/	/	/	/	503.12	/	/	/	/	/	/
24	68.09	/	/	/	/	/	/	307.40	/	/	/	/	/	/
25	50.28	23.23	8.48	/	/	/	/	83.60	166.12	94.82	/	/	/	/
26	72.18	/	/	/	/	/	/	318.01	/	/	/	/	/	/
27	71.72	28.73	/	/	/	/	/	225.89	242.61	/	/	/	/	/
28	47.32	/	/	/	/	/	/	363.75	/	/	/	/	/	/
29	102.90	/	/	/	/	/	/	215.40	/	/	/	/	/	/
30	65.45	-10.88	/	/	/	/	/	262.70	474.61	/	/	/	/	/
31	67.34	/	/	/	/	/	/	398.62	/	/	/	/	/	/
32	39.12	/	/	/	/	/	/	712.94	/	/	/	/	/	/
33	/	/	/	/	/	/	/	/	/	/	/	/	/	/
34	72.60	/	/	/	/	/	/	454.83	/	/	/	/	/	/
35	50.79	/	/	/	/	/	/	317.32	/	/	/	/	/	/
36	76.06	/	/	/	/	/	/	188.03	/	/	/	/	/	/
37	46.23	/	/	/	/	/	/	89.55	/	/	/	/	/	/
38	101.30	/	/	/	/	/	/	220.54	/	/	/	/	/	/
39	70.87	17.61	/	/	/	/	/	208.86	242.46	/	/	/	/	/
40	60.62	/	/	/	/	/	/	500.98	/	/	/	/	/	/
41	62.67	/	/	/	/	/	/	303.97	/	/	/	/	/	/
42	54.80	36.55	/	/	/	/	/	39.60	45.80	/	/	/	/	/
43	67.65	/	/	/	/	/	/	464.11	/	/	/	/	/	/
44	54.17	/	/	/	/	/	/	135.53	/	/	/	/	/	/
45	66.79	/	/	/	/	/	/	345.70	/	/	/	/	/	/
46	78.38	/	/	/	/	/	/	426.62	/	/	/	/	/	/
47	/	/	/	/	/	/	/	/	/	/	/	/	/	/
48	/	/	/	/	/	/	/	/	/	/	/	/	/	/
49	79.66	/	/	/	/	/	/	375.36	/	/	/	/	/	/
50	74.77	12.76	/	/	/	/	/	263.38	324.84	/	/	/	/	/
51	66.71	/	/	/	/	/	/	310.45	/	/	/	/	/	/
52	68.90	/	/	/	/	/	/	259.18	/	/	/	/	/	/
53	73.17	/	/	/	/	/	/	356.47	/	/	/	/	/	/
54	84.37	20.24	/	/	/	/	/	329.76	324.91	/	/	/	/	/
55	68.66	/	/	/	/	/	/	196.13	/	/	/	/	/	/
56	114.49	/	/	/	/	/	/	389.25	/	/	/	/	/	/
57	35.82	23.96	1.39	/	/	/	/	71.30	70.53	16.75	/	/	/	/
58	63.97	38.02	/	/	/	/	/	141.26	20.56	/	/	/	/	/
59	53.93	/	/	/	/	/	/	169.41	/	/	/	/	/	/
60	-5.46	-1.52	4.06	/	/	/	/	30.64	26.60	-13.41	/	/	/	/
61	81.94	/	/	/	/	/	/	395.44	/	/	/	/	/	/
62	58.06	/	/	/	/	/	/	167.82	/	/	/	/	/	/
63	100.25	/	/	/	/	/	/	56.51	/	/	/	/	/	/
64	48.67	/	/	/	/	/	/	98.70	/	/	/	/	/	/
65	94.49	/	/	/	/	/	/	194.43	/	/	/	/	/	/
66	/	/	/	/	/	/	/	/	/	/	/	/	/	/
67	62.46	/	/	/	/	/	/	233.29	/	/	/	/	/	/
68	48.86	-5.09	3.17	/	/	/	/	280.79	71.82	48.57	/	/	/	/
69	64.96	6.16	/	/	/	/	/	254.66	292.93	/	/	/	/	/
70	58.76	13.74	/	/	/	/	/	216.87	146.75	/	/	/	/	/
71	55.29	32.13	28.34	/	/	/	/	22.41	12.09	-16.74	/	/	/	/
72	66.52	/	/	/	/	/	/	364.58	/	/	/	/	/	/
73	57.38	29.56	/	/	/	/	/	58.68	23.61	/	/	/	/	/
74	71.78	/	/	/	/	/	/	312.11	/	/	/	/	/	/
75	77.29	24.41	/	/	/	/	/	286.29	186.33	/	/	/	/	/
76	78.07	/	/	/	/	/	/	320.91	/	/	/	/	/	/
77	101.76	/	/	/	/	/	/	248.77	/	/	/	/	/	/
78	52.06	/	/	/	/	/	/	128.46	/	/	/	/	/	/
79	70.76	/	/	/	/	/	/	186.05	/	/	/	/	/	/
80	74.42	/	/	/	/	/	/	374.98	/	/	/	/	/	/
81	70.60	/	/	/	/	/	/	228.42	/	/	/	/	/	/
82	84.39	/	/	/	/	/	/	281.58	/	/	/	/	/	/
83	69.98	/	/	/	/	/	/	248.82	/	/	/	/	/	/
84	65.82	/	/	/	/	/	/	292.76	/	/	/	/	/	/
85	-8.02	22.06	/	/	/	/	/	22.18	25.04	/	/	/	/	/
86	76.89	/	/	/	/	/	/	420.02	/	/	/	/	/	/
87	69.28	/	/	/	/	/	/	307.66	/	/	/	/	/	/
88	64.02	/	/	/	/	/	/	347.93	/	/	/	/	/	/
89	78.86	/	/	/	/	/	/	283.22	/	/	/	/	/	/
90	/	/	/	/	/	/	/	/	/	/	/	/	/	/
91	67.75	/	/	/	/	/	/	375.52	/	/	/	/	/	/
92	78.61	/	/	/	/	/	/	330.50	/	/	/	/	/	/
93	70.84	13.75	/	/	/	/	/	246.87	223.40	/	/	/	/	/
94	58.69	2.47	/	/	/	/	/	210.26	275.19	/	/	/	/	/
95	77.70	/	/	/	/	/	/	389.30	/	/	/	/	/	/
96	/	/	/	/	/	/	/	/	/	/	/	/	/	/
97	64.89	/	/	/	/	/	/	293.51	/	/	/	/	/	/
98	46.11	27.67	/	/	/	/	/	125.55	178.99	/	/	/	/	/
99	-2.81	0.29	-5.00	/	/	/	/	24.82	37.09	53.00	/	/	/	/
100	-5.84	0.35	29.04	/	/	/	/	-2.90	133.59	9.74	/	/	/	/

Appendix Table B.3d Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 100 length measurements using the two partitions for grouping the Red mullet data.

Sample size = 100 length measurements														
% Bias														
1 cm														
	mean 1	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*mean 7*	*SD 1*	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*	*SD 7*
1	0.13	-32.16	-22.37	-29.91	/	/	/	-75.93	-90.95	-90.82	-91.42	/	/	/
2	-1.67	-34.41	/	/	/	/	/	-50.37	-85.02	/	/	/	/	/
3	8.25	/	/	/	/	/	/	-80.11	/	/	/	/	/	/
4	-2.68	-34.73	/	/	/	/	/	-82.28	-93.47	/	/	/	/	/
5	-6.42	/	/	/	/	/	/	-90.96	/	/	/	/	/	/
6	/	/	/	/	/	/	/	/	/	/	/	/	/	/
7	3.32	/	/	/	/	/	/	-55.69	/	/	/	/	/	/
8	6.58	-30.51	-16.42	/	/	/	/	-90.77	-90.95	-89.56	/	/	/	/
9	-9.21	-39.20	-22.67	/	/	/	/	-86.95	-86.66	-87.01	/	/	/	/
10	-8.00	-31.75	/	/	/	/	/	-79.26	-85.63	/	/	/	/	/
11	-13.16	-5.54	-18.04	/	/	/	/	-89.63	-88.27	-87.01	/	/	/	/
12	-11.84	-39.78	-21.05	/	/	/	/	-89.63	-93.33	-91.71	/	/	/	/
13	-9.26	-40.35	-24.68	/	/	/	/	-82.28	-89.76	-92.62	/	/	/	/
14	4.61	-2.24	/	/	/	/	/	-79.26	-81.14	/	/	/	/	/
15	-13.82	-42.59	-50.67	/	/	/	/	-85.34	-84.54	-88.27	/	/	/	/
16	4.24	2.71	/	/	/	/	/	-90.25	-90.46	/	/	/	/	/
17	-8.55	-37.72	-47.47	-52.02	/	/	/	-83.76	-83.82	-91.90	-93.86	/	/	/
18	51.12	/	/	/	/	/	/	-82.93	/	/	/	/	/	/
19	-5.32	-35.24	-24.42	-28.39	-28.67	/	/	-82.87	-86.66	-85.64	-86.61	-88.49	/	/
20	-4.98	-37.71	-19.77	/	/	/	/	-82.87	-90.04	-85.48	/	/	/	/
21	-6.13	-37.32	-21.54	/	/	/	/	-80.11	-86.66	-85.19	/	/	/	/
22	-0.36	/	/	/	/	/	/	-50.37	/	/	/	/	/	/
23	-6.53	-36.28	-46.37	/	/	/	/	-61.31	-88.27	-90.47	/	/	/	/
24	1.38	-29.12	/	/	/	/	/	-65.69	-79.30	/	/	/	/	/
25	-0.11	-31.94	-25.01	-13.05	/	/	/	-78.05	-88.27	-90.82	-91.42	/	/	/
26	-4.94	-36.06	/	/	/	/	/	-78.05	-85.02	/	/	/	/	/
27	0.66	/	/	/	/	/	/	-79.26	/	/	/	/	/	/
28	4.61	/	/	/	/	/	/	-79.26	/	/	/	/	/	/
29	-4.56	-37.30	-24.02	-27.88	/	/	/	-80.47	-93.33	-92.62	-93.93	/	/	/
30	-1.62	-35.24	-45.22	-34.26	-35.10	-32.07	/	-83.11	-90.57	-83.79	-86.37	-90.30	-90.19	/
31	-7.58	-39.09	-44.17	/	/	/	/	-83.76	-86.66	-89.56	/	/	/	/
32	-3.11	-36.48	/	/	/	/	/	-78.76	-92.51	/	/	/	/	/
33	-2.26	/	/	/	/	/	/	-81.83	/	/	/	/	/	/
34	-2.62	-36.06	-45.32	-23.78	/	/	/	-81.78	-88.27	-87.59	-89.33	/	/	/
35	-6.45	-38.81	-46.28	-50.56	-35.89	/	/	-82.64	-92.30	-87.77	-93.93	-92.16	/	/
36	-3.90	-36.89	/	/	/	/	/	-82.28	-90.93	/	/	/	/	/
37	-6.53	-38.22	-26.00	/	/	/	/	-82.28	-88.60	-83.49	/	/	/	/
38	-1.26	-27.40	-21.71	/	/	/	/	-71.07	-90.57	-90.82	/	/	/	/
39	-4.17	-36.77	-45.60	-30.83	-28.40	/	/	-84.93	-76.38	-88.75	-90.36	-92.72	/	/
40	-0.13	-31.53	/	/	/	/	/	-73.38	-92.51	/	/	/	/	/
41	0.34	-33.59	-19.02	/	/	/	/	-68.03	-91.19	-85.28	/	/	/	/
42	-9.66	-37.16	-22.59	-28.46	/	/	/	-76.69	-89.11	-93.97	-93.93	/	/	/
43	-0.10	-33.93	/	/	/	/	/	-79.26	-71.97	/	/	/	/	/
44	-1.90	0.03	/	/	/	/	/	-73.90	-79.99	/	/	/	/	/
45	-11.26	-39.55	-19.39	/	/	/	/	-73.90	-88.94	-92.62	/	/	/	/
46	-10.31	-37.37	-47.17	/	/	/	/	-76.17	-85.02	-86.35	/	/	/	/
47	6.63	/	/	/	/	/	/	-82.28	/	/	/	/	/	/
48	-5.48	/	/	/	/	/	/	-81.54	/	/	/	/	/	/
49	-9.56	-39.61	/	/	/	/	/	-80.11	-85.63	/	/	/	/	/
50	-6.90	-36.96	-46.48	-27.88	/	/	/	-73.81	-77.80	-95.15	-93.93	/	/	/
51	9.21	-6.36	-16.75	/	/	/	/	-86.95	-81.14	-92.62	/	/	/	/
52	-2.06	-31.78	-16.42	/	/	/	/	-74.33	-84.32	-89.56	/	/	/	/
53	-10.63	-33.59	-43.90	/	/	/	/	-79.26	-89.65	-83.79	/	/	/	/
54	-5.62	-38.54	/	/	/	/	/	-84.69	-86.66	/	/	/	/	/
55	-2.87	-28.24	/	/	/	/	/	-80.11	-78.89	/	/	/	/	/
56	2.44	-4.30	16.89	/	/	/	/	-84.93	-90.57	-83.79	/	/	/	/
57	-2.19	-35.72	-22.70	/	/	/	/	-86.95	-87.23	-94.14	/	/	/	/
58	-10.22	/	/	/	/	/	/	-87.47	/	/	/	/	/	/
59	-1.59	-36.38	-46.92	/	/	/	/	-77.30	-88.60	-85.96	/	/	/	/
60	-2.39	-34.54	1.20	/	/	/	/	-77.19	-85.02	-93.97	/	/	/	/
61	0.41	-32.76	/	/	/	/	/	-86.21	-88.27	/	/	/	/	/
62	-0.41	-4.84	-17.43	/	/	/	/	-73.52	-85.63	-83.41	/	/	/	/
63	-3.90	-35.65	-16.75	/	/	/	/	-82.28	-90.57	-92.62	/	/	/	/
64	-6.78	/	/	/	/	/	/	-83.20	/	/	/	/	/	/
65	-4.61	-37.71	-47.90	-33.11	-33.84	/	/	-84.93	-90.93	-91.47	-93.93	-94.22	/	/
66	-7.07	-36.44	-45.67	/	/	/	/	-71.63	-79.10	-92.91	/	/	/	/
67	4.61	/	/	/	/	/	/	-85.68	/	/	/	/	/	/
68	-5.23	-33.59	/	/	/	/	/	-70.68	-88.27	/	/	/	/	/
69	-9.06	-35.63	-43.84	/	/	/	/	-84.22	-86.66	-92.62	/	/	/	/
70	-7.42	-37.71	/	/	/	/	/	-84.22	-89.41	/	/	/	/	/
71	-11.24	-39.57	-22.37	/	/	/	/	-74.11	-84.14	-89.56	/	/	/	/
72	-2.20	/	/	/	/	/	/	-88.12	/	/	/	/	/	/
73	-3.40	-36.81	-46.43	/	/	/	/	-80.40	-80.01	-88.27	/	/	/	/
74	-2.36	-34.21	-15.76	/	/	/	/	-77.30	-87.04	-89.56	/	/	/	/
75	-3.82	-34.74	-2.88	/	/	/	/	-75.93	-85.63	-83.49	/	/	/	/
76	-3.29	-34.39	/	/	/	/	/	-84.93	-79.53	/	/	/	/	/
77	-3.79	-35.18	/	/	/	/	/	-82.56	-83.55	/	/	/	/	/
78	-6.58	-37.76	-47.10	-25.26	/	/	/	-91.43	-81.14	-90.80	-93.59	/	/	/
79	-7.24	-31.53	-16.12	/	/	/	/	-81.54	-90.57	-87.01	/	/	/	/
80	-5.58	/	/	/	/	/	/	-83.76	/	/	/	/	/	/
81	-9.21	-38.76	-15.43	/	/	/	/	-91.88	-90.95	-94.14	/	/	/	/
82	-9.54	-31.94	-43.84	/	/	/	/	-73.81	-90.46	-94.14	/	/	/	/
83	-3.29	-34.91	/	/	/	/	/	-84.93	-80.58	/	/	/	/	/
84	-0.30	-32.42	-20.38	/	/	/	/	-86.32	-88.79	-89.56	/	/	/	/
85	-8.48	-36.33	-43.84	-34.57	-35.75	/	/	-73.90	-74.67	-92.62	-91.42	-94.85	/	/
86	-8.48	-34.76	-19.90	/	/	/	/	-73.90	-85.02	-92.91	/	/	/	/
87	-1.73	-32.76	-23.47	/	/	/	/	-86.21	-90.76	-87.94	/	/	/	/
88	-7.24	-38.03	/	/	/	/	/	-82.87	-77.82	/	/	/	/	/
89	-3.52	-35.24	-23.21	-9.27	/	/	/	-88.12	-85.02	-92.91	-93.93	/	/	/
90	-1.00	-34.77	-21.05	-21.48	/	/	/	-83.76	-87.65	-90.82	-93.93	/	/	/
91	12.17	1.89	-14.77	/	/	/	/	-72.31	-86.66	-92.62	/	/	/	/
92	-8.55	-39.90	-18.79	/	/	/	/	-81.54	-87.86	-88.27	/	/	/	/
93	-1.86	-33.07	-16.09	/	/	/	/	-60.50	-87.40	-94.78	/	/	/	/
94	-3.83	-35.05	/	/	/	/	/	-83.76	-87.26	/	/	/	/	/
95	-8.55	-39.13	-47.83	-25.26	-15.06	/	/	-83.76	-87.62	-89.98	-87.87	-94.85	/	/
96	80.92	/	/	/	/	/	/	-83.76	/	/	/	/	/	/
97	-4.87	-37.52	-18.05	/	/	/	/	-85.68	-85.63	-86.40	/	/	/	/
98	-2.95	/	/	/	/	/	/	-83.76	/	/	/	/	/	/
99	4.61	0.07	/	/	/	/	/	-85.83	-85.36	/	/	/	/	/
100	0.66	-34.74	/	/	/	/	/	-87.89	-93.79	/	/	/	/	/

Appendix Table B.4a Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 200 length measurements using the two partitions for grouping the Red mullet data.

	Sample size = 200 length measurements													
	Estimates													
	Birgè and Rozenholc algorithm													
	mean 1 (cm)	*mean 2* (cm)	*mean 3* (cm)	*mean 4* (cm)	*mean 5* (cm)	*mean 6* (cm)	*mean 7* (cm)	*SD 1* (cm)	*SD 2* (cm)	*SD 3* (cm)	*SD 4* (cm)	*SD 5* (cm)	*SD 6* (cm)	*SD 7* (cm)
1	13.18	15.01	/	/	/	/	/	2.19	3.08	/	/	/	/	/
2	10.78	13.69	/	/	/	/	/	1.88	2.86	/	/	/	/	/
3	12.53	14.81	/	/	/	/	/	3.34	3.08	/	/	/	/	/
4	7.22	11.51	15.49	18.39	/	/	/	0.75	0.95	1.27	0.72	/	/	/
5	7.19	11.34	14.87	17.64	/	/	/	0.73	0.87	1.97	1.58	/	/	/
6	12.50	/	/	/	/	/	/	2.67	/	/	/	/	/	/
7	7.20	13.07	18.13	/	/	/	/	0.89	1.99	1.21	/	/	/	/
8	7.15	12.07	15.63	/	/	/	/	1.14	1.60	1.58	/	/	/	/
9	7.05	11.44	14.76	/	/	/	/	0.72	0.75	1.40	/	/	/	/
10	12.74	14.39	/	/	/	/	/	2.38	2.76	/	/	/	/	/
11	13.45	14.14	/	/	/	/	/	2.32	3.19	/	/	/	/	/
12	12.87	/	/	/	/	/	/	3.13	/	/	/	/	/	/
13	7.68	12.73	14.43	16.84	/	/	/	0.97	1.52	2.68	1.81	/	/	/
14	11.70	14.64	15.29	/	/	/	/	1.22	1.50	1.45	/	/	/	/
15	7.02	11.66	17.18	/	/	/	/	0.58	1.16	0.96	/	/	/	/
16	12.40	13.66	/	/	/	/	/	3.03	2.91	/	/	/	/	/
17	7.21	11.80	15.32	/	/	/	/	1.04	1.14	1.60	/	/	/	/
18	7.22	12.14	13.23	17.30	/	/	/	0.68	1.00	1.64	0.87	/	/	/
19	15.11	/	/	/	/	/	/	2.21	/	/	/	/	/	/
20	7.22	11.76	15.61	18.09	/	/	/	0.96	0.96	1.27	1.73	/	/	/
21	11.45	14.05	/	/	/	/	/	1.35	1.93	/	/	/	/	/
22	13.08	/	/	/	/	/	/	3.02	/	/	/	/	/	/
23	11.75	/	/	/	/	/	/	1.54	/	/	/	/	/	/
24	12.12	/	/	/	/	/	/	2.92	/	/	/	/	/	/
25	11.62	14.84	19.41	/	/	/	/	1.02	0.76	0.59	/	/	/	/
26	11.54	14.06	/	/	/	/	/	1.20	1.81	/	/	/	/	/
27	14.99	/	/	/	/	/	/	3.22	/	/	/	/	/	/
28	11.50	15.46	/	/	/	/	/	1.87	2.78	/	/	/	/	/
29	7.32	11.33	14.73	16.02	/	/	/	1.09	1.20	1.69	1.39	/	/	/
30	7.18	11.87	15.75	16.09	/	/	/	0.87	1.13	1.11	1.54	/	/	/
31	7.26	12.01	14.53	17.62	/	/	/	0.64	1.22	1.19	0.64	/	/	/
32	7.29	11.53	15.15	15.51	19.73	/	/	0.68	0.73	0.75	1.18	1.26	/	/
33	12.44	14.12	15.54	/	/	/	/	1.79	2.25	1.35	/	/	/	/
34	7.21	11.21	11.89	15.26	20.75	/	/	0.58	0.73	1.39	0.89	0.81	/	/
35	11.95	16.50	/	/	/	/	/	2.05	2.16	/	/	/	/	/
36	11.72	15.56	19.03	/	/	/	/	0.96	1.39	1.51	/	/	/	/
37	7.11	12.05	15.55	/	/	/	/	0.93	0.93	1.68	/	/	/	/
38	12.58	14.40	15.84	/	/	/	/	2.11	2.56	1.56	/	/	/	/
39	12.05	16.28	/	/	/	/	/	1.24	1.32	/	/	/	/	/
40	7.15	12.04	13.66	/	/	/	/	0.94	0.94	3.03	/	/	/	/
41	13.22	15.30	/	/	/	/	/	2.55	3.35	/	/	/	/	/
42	7.24	11.87	15.35	18.74	/	/	/	0.73	1.05	1.29	1.27	/	/	/
43	6.98	11.38	15.00	16.18	/	/	/	0.67	0.64	1.05	1.79	/	/	/
44	7.13	11.94	14.45	17.08	/	/	/	0.67	1.13	3.19	1.64	/	/	/
45	7.32	11.48	15.16	18.58	/	/	/	0.63	0.67	0.91	0.84	/	/	/
46	13.03	13.92	/	/	/	/	/	3.03	3.65	/	/	/	/	/
47	12.78	/	/	/	/	/	/	2.72	/	/	/	/	/	/
48	13.26	/	/	/	/	/	/	3.33	/	/	/	/	/	/
49	7.18	11.53	14.34	18.23	/	/	/	1.05	1.22	2.03	1.08	/	/	/
50	7.41	12.16	15.15	/	/	/	/	0.55	0.98	1.18	/	/	/	/
51	13.06	/	/	/	/	/	/	2.81	/	/	/	/	/	/
52	13.18	/	/	/	/	/	/	2.64	/	/	/	/	/	/
53	11.40	15.26	/	/	/	/	/	0.94	1.17	/	/	/	/	/
54	7.17	14.12	16.35	/	/	/	/	0.56	1.07	0.99	/	/	/	/
55	7.25	12.11	14.73	/	/	/	/	0.70	1.19	1.06	/	/	/	/
56	7.23	11.95	16.55	19.44	/	/	/	0.67	1.06	0.79	0.67	/	/	/
57	11.45	15.12	/	/	/	/	/	1.61	2.89	/	/	/	/	/
58	15.07	/	/	/	/	/	/	1.45	/	/	/	/	/	/
59	7.32	11.46	13.67	17.36	/	/	/	0.56	0.80	0.78	0.72	/	/	/
60	13.33	/	/	/	/	/	/	2.92	/	/	/	/	/	/
61	7.13	11.68	15.08	18.45	/	/	/	0.60	0.97	1.41	1.28	/	/	/
62	12.68	/	/	/	/	/	/	2.89	/	/	/	/	/	/
63	6.87	11.38	14.17	17.51	/	/	/	0.66	1.03	1.77	1.67	/	/	/
64	7.16	11.76	14.82	17.44	/	/	/	0.63	0.97	0.90	0.96	/	/	/
65	12.97	/	/	/	/	/	/	2.33	/	/	/	/	/	/
66	7.09	11.52	14.72	/	/	/	/	0.75	0.89	1.43	/	/	/	/
67	7.00	11.23	/	/	/	/	/	0.74	1.04	/	/	/	/	/
68	13.11	14.22	/	/	/	/	/	2.72	2.92	/	/	/	/	/
69	12.86	/	/	/	/	/	/	2.70	/	/	/	/	/	/
70	11.55	14.88	/	/	/	/	/	1.37	2.06	/	/	/	/	/
71	11.40	15.23	/	/	/	/	/	1.32	2.06	/	/	/	/	/
72	7.22	11.93	13.56	15.87	/	/	/	0.74	1.36	0.99	0.48	/	/	/
73	7.14	11.83	15.02	18.59	/	/	/	0.75	1.04	1.63	1.22	/	/	/
74	7.17	11.90	15.05	17.74	/	/	/	0.70	1.08	0.92	1.13	/	/	/
75	7.26	11.81	14.47	15.07	/	/	/	0.97	1.00	1.75	1.24	/	/	/
76	7.08	11.63	14.86	16.75	18.47	/	/	0.76	0.82	0.87	1.33	1.10	/	/
77	7.13	12.00	14.97	/	/	/	/	0.64	1.38	1.81	/	/	/	/
78	13.08	/	/	/	/	/	/	3.44	/	/	/	/	/	/
79	6.93	11.75	16.66	/	/	/	/	0.85	0.92	1.36	/	/	/	/
80	12.29	/	/	/	/	/	/	3.66	/	/	/	/	/	/
81	7.35	12.11	16.92	/	/	/	/	0.97	1.45	1.87	/	/	/	/
82	7.07	11.87	16.88	/	/	/	/	0.67	0.83	1.76	/	/	/	/
83	11.64	14.38	18.43	/	/	/	/	1.01	2.91	2.10	/	/	/	/
84	12.80	/	/	/	/	/	/	1.59	/	/	/	/	/	/
85	12.89	/	/	/	/	/	/	2.41	/	/	/	/	/	/
86	13.02	/	/	/	/	/	/	2.14	/	/	/	/	/	/
87	7.03	16.73	/	/	/	/	/	0.78	1.56	/	/	/	/	/
88	7.07	11.49	15.58	14.99	/	/	/	1.01	0.85	1.46	2.08	/	/	/
89	7.07	11.90	15.33	18.27	/	/	/	0.82	0.93	1.15	1.27	/	/	/
90	12.93	/	/	/	/	/	/	2.70	/	/	/	/	/	/
91	11.30	/	/	/	/	/	/	0.99	/	/	/	/	/	/
92	7.24	11.77	16.56	/	/	/	/	0.99	1.17	1.54	/	/	/	/
93	11.71	15.62	17.76	/	/	/	/	0.82	1.22	1.48	/	/	/	/
94	13.98	/	/	/	/	/	/	1.92	/	/	/	/	/	/
95	12.52	/	/	/	/	/	/	2.62	/	/	/	/	/	/
96	6.98	11.95	14.32	16.95	/	/	/	0.59	0.93	1.53	1.60	/	/	/
97	12.25	15.28	/	/	/	/	/	1.25	2.10	/	/	/	/	/
98	13.17	/	/	/	/	/	/	2.85	/	/	/	/	/	/
99	7.54	12.71	13.98	17.07	/	/	/	1.37	1.79	3.28	1.83	/	/	/
100	7.11	11.48	16.29	17.21	/	/	/	0.67	0.92	2.08	1.75	/	/	/

Appendix Table B.4b Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 200 length measurements using the two partitions for grouping the Red mullet data.

Sample size = 200 length measurements														
Estimates														
1 cm														
	mean 1 (cm)	*mean 2 (cm)*	*mean 3 (cm)*	*mean 4 (cm)*	*mean 5 (cm)*	*mean 6 (cm)*	*mean 7 (cm)*	*SD 1 (cm)*	*SD 2 (cm)*	*SD 3 (cm)*	*SD 4 (cm)*	*SD 5 (cm)*	*SD 6 (cm)*	*SD 7 (cm)*
1	6.85	7.53	11.26	11.78	12.02	12.30	/	0.12	0.14	0.17	0.11	0.11	0.08	/
2	7.07	7.37	11.95	12.29	12.52	12.80	15.35	0.32	0.11	0.08	0.13	0.11	0.06	0.08
3	7.03	8.23	11.65	12.29	12.77	14.25	15.87	0.11	0.24	0.09	0.12	0.12	0.11	0.13
4	7.58	7.82	11.55	16.12	/	/	/	0.15	0.14	0.10	0.14	/	/	/
5	6.69	6.99	7.91	8.45	11.22	11.55	11.95	0.13	0.14	0.10	0.14	0.11	0.11	0.08
6	6.58	7.16	8.40	10.45	10.95	11.49	11.93	0.11	0.17	0.08	0.17	0.17	0.13	0.10
7	6.90	7.47	7.95	11.45	11.80	12.46	12.85	0.15	0.13	0.16	0.09	0.15	0.17	0.12
8	6.58	6.98	7.88	10.49	12.43	14.50	/	0.11	0.12	0.12	0.19	0.11	0.07	/
9	7.51	7.97	8.22	10.52	11.47	12.02	13.25	0.10	0.13	0.12	0.08	0.09	0.08	0.12
10	7.19	7.42	7.81	11.47	12.09	12.43	13.60	0.11	0.15	0.06	0.19	0.11	0.13	0.08
11	6.95	8.13	12.80	15.38	16.60	17.05	/	0.12	0.13	0.08	0.11	0.07	0.17	/
12	6.75	7.55	8.07	11.55	12.01	12.50	14.10	0.22	0.14	0.15	0.12	0.15	0.08	0.08
13	7.93	11.31	11.62	13.15	15.25	15.93	17.97	0.66	0.14	0.08	0.11	0.11	0.21	0.13
14	6.82	7.23	11.25	12.75	16.15	17.76	/	0.11	0.13	0.09	0.12	0.11	0.21	/
15	6.99	7.31	7.92	11.42	11.95	12.04	15.07	0.11	0.14	0.17	0.10	0.13	0.17	0.14
16	6.50	6.96	8.02	11.15	11.65	12.86	13.90	0.19	0.21	0.12	0.11	0.09	0.17	0.19
17	6.90	7.44	8.27	10.85	11.91	12.97	12.61	0.12	0.11	0.13	0.17	0.18	0.32	0.13
18	6.99	7.69	8.57	11.75	12.52	13.99	/	0.10	0.15	0.13	0.12	0.11	0.11	/
19	7.55	7.88	8.48	11.81	12.20	12.90	16.64	0.29	0.11	0.14	0.08	0.11	0.06	0.17
20	7.25	7.78	11.33	12.00	16.79	/	/	0.10	0.12	0.21	0.12	0.19	/	/
21	6.86	7.62	8.01	11.35	11.74	12.15	/	0.13	0.16	0.11	0.12	0.07	0.12	/
22	7.07	7.59	11.35	11.90	12.69	15.38	/	0.15	0.15	0.12	0.07	0.11	0.21	/
23	6.80	7.35	7.87	8.31	12.16	12.50	12.95	0.11	0.13	0.26	0.17	0.15	0.08	0.10
24	7.00	7.68	8.20	12.18	13.65	15.65	/	0.19	0.12	0.12	0.14	0.17	0.10	/
25	6.96	7.35	8.10	11.51	11.99	12.45	15.65	0.17	0.21	0.07	0.13	0.19	0.16	0.09
26	6.73	8.12	8.65	11.15	11.85	12.65	13.76	0.10	0.19	0.10	0.11	0.12	0.13	0.17
27	6.69	7.65	8.00	12.41	12.85	15.90	16.33	0.19	0.15	0.06	0.13	0.12	0.19	0.18
28	7.21	7.42	7.83	8.11	12.65	17.69	/	0.11	0.17	0.13	0.22	0.12	0.19	/
29	7.15	7.72	11.72	12.19	12.85	14.20	/	0.13	0.11	0.07	0.17	0.12	0.06	/
30	7.02	7.48	7.77	12.35	13.15	13.40	15.41	0.09	0.14	0.15	0.09	0.11	0.08	0.11
31	7.15	7.61	8.15	11.97	12.51	12.95	13.40	0.11	0.13	0.08	0.14	0.21	0.10	0.15
32	7.17	7.88	12.35	12.75	16.00	16.60	/	0.16	0.21	0.09	0.12	0.15	0.08	/
33	6.97	7.21	7.86	12.17	15.12	/	/	0.15	0.13	0.12	0.10	0.08	/	/
34	6.88	7.96	12.02	12.49	15.95	/	/	0.11	0.17	0.07	0.13	0.12	/	/
35	6.97	7.83	8.38	11.00	13.05	16.78	17.73	0.12	0.23	0.11	0.06	0.11	0.18	0.13
36	6.85	7.33	8.40	10.92	11.82	/	/	0.16	0.14	0.12	0.11	0.24	/	/
37	6.75	7.68	7.92	11.72	12.66	13.15	13.55	0.12	0.49	0.12	0.07	0.16	0.12	0.17
38	6.63	7.32	7.77	8.55	14.15	14.42	15.49	0.20	0.13	0.11	0.11	0.12	0.08	0.19
39	7.15	7.51	8.18	12.11	12.85	17.27	/	0.12	0.07	0.12	0.13	0.08	0.32	/
40	6.68	7.28	8.13	11.50	12.09	12.52	15.35	0.15	0.19	0.12	0.19	0.19	0.07	0.12
41	6.97	7.80	8.25	12.90	15.62	18.73	/	0.08	0.13	0.11	0.12	0.08	0.13	/
42	7.10	7.79	11.75	12.05	12.35	13.30	15.20	0.24	0.57	0.11	0.10	0.11	0.12	0.06
43	6.96	7.09	7.80	11.19	12.08	12.46	15.95	0.17	0.18	0.14	0.12	0.11	0.14	0.12
44	7.09	7.44	7.77	8.16	8.90	11.42	12.48	0.15	0.10	0.11	0.08	0.08	0.12	0.11
45	6.75	7.51	8.53	10.93	11.60	11.95	12.95	0.08	0.13	0.14	0.13	0.12	0.10	0.12
46	6.94	7.29	8.41	11.35	12.35	12.95	13.20	0.10	0.11	0.13	0.17	0.16	0.12	0.08
47	6.65	7.32	7.91	11.35	11.85	16.65	/	0.08	0.18	0.12	0.09	0.13	0.17	/
48	6.83	7.40	7.85	10.95	11.85	12.30	12.62	0.12	0.10	0.11	0.17	0.12	0.08	0.08
49	6.55	7.01	7.38	8.45	12.38	12.80	17.00	0.09	0.13	0.19	0.09	0.11	0.19	0.08
50	7.17	7.67	7.96	8.15	11.05	12.04	13.30	0.12	0.11	0.09	0.15	0.17	0.11	0.19
51	6.79	7.32	8.48	11.39	12.05	13.95	15.25	0.20	0.10	0.11	0.13	0.12	0.12	0.11
52	7.39	8.02	8.62	11.89	14.90	16.86	/	0.23	0.12	0.10	0.23	0.08	0.17	/
53	7.67	8.11	11.77	12.63	14.85	15.10	15.72	0.24	0.10	0.20	0.09	0.09	0.06	0.07
54	6.84	7.30	11.20	11.74	12.15	14.89	17.10	0.10	0.11	0.07	0.22	0.21	0.19	0.06
55	7.47	7.70	8.05	12.85	15.98	/	/	0.15	0.14	0.12	0.12	0.18	/	/
56	7.13	7.61	11.05	11.90	12.35	12.95	13.20	0.11	0.29	0.11	0.19	0.09	0.12	0.08
57	6.97	7.67	8.35	11.62	11.90	12.65	12.93	0.14	0.11	0.12	0.08	0.12	0.12	0.07
58	6.85	7.88	11.35	12.10	12.33	12.80	14.90	0.10	0.23	0.13	0.12	0.13	0.12	0.15
59	7.35	7.83	8.14	11.81	12.19	16.15	/	0.16	0.14	0.18	0.13	0.11	0.17	/
60	7.06	7.63	8.21	11.82	12.25	13.42	/	0.20	0.16	0.10	0.12	0.13	0.07	/
61	7.28	7.93	11.25	12.45	12.75	/	/	0.10	0.16	0.17	0.08	0.09	/	/
62	6.83	7.17	8.06	11.75	12.01	12.85	13.15	0.08	0.12	0.16	0.12	0.17	0.11	0.12
63	6.54	7.38	7.95	8.18	12.21	14.00	15.90	0.12	0.16	0.13	0.11	0.13	0.07	0.07
64	6.69	7.22	12.28	12.52	/	/	/	0.18	0.11	0.21	0.10	/	/	/
65	6.85	7.40	8.25	13.50	/	/	/	0.16	0.11	0.08	0.12	/	/	/
66	7.45	8.75	11.92	12.59	15.83	/	/	0.20	0.16	0.07	0.12	0.08	/	/
67	6.67	7.00	7.54	7.82	11.68	12.43	/	0.14	0.11	0.08	0.12	0.11	0.21	/
68	6.52	7.55	7.97	11.30	11.76	12.50	18.25	0.08	0.14	0.10	0.19	0.15	0.08	0.12
69	6.40	7.29	8.15	12.05	12.95	14.10	14.50	0.07	0.16	0.14	0.09	0.11	0.19	0.08
70	7.32	8.31	11.62	12.68	13.95	14.95	16.65	0.21	0.11	0.24	0.11	0.17	0.11	0.12
71	6.77	7.62	8.45	12.11	12.97	18.10	/	0.14	0.41	0.09	0.11	0.12	0.19	/
72	6.20	7.96	11.54	11.95	14.14	14.60	14.99	0.08	0.25	0.19	0.12	0.17	0.06	0.11
73	7.02	7.46	11.42	12.28	12.61	14.85	/	0.06	0.27	0.10	0.17	0.13	0.12	/
74	6.69	7.32	7.85	/	/	/	/	0.13	0.10	0.12	/	/	/	/
75	7.51	7.70	8.15	11.59	13.88	/	/	0.12	0.08	0.18	0.11	0.18	/	/
76	6.87	7.39	7.73	12.28	12.50	14.72	15.85	0.13	0.12	0.19	0.12	0.07	0.10	0.11
77	6.45	7.61	8.03	11.35	11.75	12.20	12.75	0.11	0.09	0.12	0.09	0.09	0.07	0.12
78	6.45	7.18	7.71	11.30	11.60	13.00	15.25	0.16	0.16	0.17	0.11	0.08	0.11	0.17
79	7.26	7.68	7.97	8.50	10.70	11.69	11.95	0.08	0.09	0.23	0.11	0.15	0.13	0.16
80	7.39	8.08	11.03	11.90	12.54	13.29	14.55	0.19	0.12	0.08	0.07	0.20	0.19	0.12
81	6.85	7.38	8.60	11.45	13.01	14.82	15.10	0.09	0.16	0.07	0.09	0.06	0.11	0.08
82	6.81	7.31	7.93	8.47	11.50	12.51	13.65	0.11	0.13	0.13	0.13	0.06	0.13	0.11
83	6.68	6.91	7.76	8.64	10.97	11.30	11.95	0.21	0.21	0.12	0.15	0.13	0.08	0.12
84	7.05	7.95	8.32	11.65	12.13	13.21	14.05	0.13	0.13	0.07	0.11	0.08	0.11	0.11
85	7.16	7.84	8.39	14.35	14.75	17.70	/	0.22	0.10	0.13	0.17	0.10	0.08	/
86	7.38	8.50	11.87	14.02	15.69	/	/	0.29	0.11	0.13	0.16	0.19	/	/
87	6.55	7.09	7.80	11.62	12.43	13.32	15.28	0.12	0.13	0.18	0.07	0.13	0.08	0.12
88	6.88	7.18	7.85	11.12	12.75	/	/	0.11	0.11	0.10	0.08	0.16	/	/
89	6.52	7.58	8.25	11.83	12.18	15.47	/	0.08	0.25	0.10	0.10	0.11	0.09	/
90	8.07	11.72	12.53	13.87	14.77	15.25	/	0.14	0.07	0.13	0.13	0.13	0.17	/
91	6.90	7.23	10.80	11.49	12.07	12.51	12.92	0.11	0.26	0.19	0.13	0.13	0.14	0.08
92	6.81	7.07	7.47	11.12	12.72	13.25	14.02	0.13	0.15	0.16	0.07	0.12	0.12	0.07
93	6.87	7.41	7.87	11.44	12.15	12.55	12.95	0.21	0.13	0.13	0.22	0.11	0.10	0.10
94	6.65	7.02	11.40	11.88	12.16	14.62	15.80	0.10	0.07	0.16	0.11	0.13	0.08	0.07
95	6.96	7.62	8.11	11.41	15.50	/	/	0.19	0.13	0.10	0.12	0.12	/	/
96	7.03	7.37	7.71	8.46	10.95	11.45	12.72	0.15	0.13	0.12	0.15	0.12	0.12	0.07
97	6.77	8.51	10.90	11.97	12.97	17.85	/	0.09	0.47	0.08	0.13	0.32	0.17	/
98	6.65	7.37	8.51	11.05	11.72	12.35	12.74	0.11	0.14	0.11	0.12	0.08	0.13	0.22
99	7.15	7.45	7.87	11.82	12.19	12.95	13.95	0.12	0.10	0.12	0.11	0.11	0.12	0.17
100	6.85	7.13	7.54	11.01	11.87	12.25	15.75	0.11	0.06	0.24	0.18	0.15	0.16	0.12

Appendix Table B.4c Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 200 length measurements using the two partitions for grouping the Red mullet data.

Sample size = 200 length measurements														
% Bias														
Birgè and Rozenholc algorithm														
	mean 1	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*mean 7*	*SD 1*	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*	*SD 7*
1	73.44	23.80	/	/	/	/	/	236.22	242.30	/	/	/	/	/
2	41.82	12.95	/	/	/	/	/	189.16	217.27	/	/	/	/	/
3	64.82	22.16	/	/	/	/	/	412.83	241.98	/	/	/	/	/
4	-4.96	-5.07	2.34	6.98	/	/	/	15.76	5.12	10.02	-48.54	/	/	/
5	-5.34	-6.48	-1.78	2.59	/	/	/	11.84	-3.23	70.93	12.50	/	/	/
6	64.48	/	/	/	/	/	/	309.93	/	/	/	/	/	/
7	-5.26	7.86	19.78	/	/	/	/	37.38	120.98	5.42	/	/	/	/
8	-5.90	-0.41	3.27	/	/	/	/	74.74	77.69	36.98	/	/	/	/
9	-7.19	-5.60	-2.48	/	/	/	/	10.83	-17.23	21.50	/	/	/	/
10	67.60	18.72	/	/	/	/	/	266.09	206.08	/	/	/	/	/
11	76.99	16.67	/	/	/	/	/	256.67	254.51	/	/	/	/	/
12	69.37	/	/	/	/	/	/	380.32	/	/	/	/	/	/
13	1.05	5.04	-4.63	-2.07	/	/	/	48.88	68.40	132.84	28.98	/	/	/
14	53.98	20.78	1.05	/	/	/	/	88.21	66.28	26.00	/	/	/	/
15	-7.58	-3.81	13.48	/	/	/	/	-11.40	28.45	-16.94	/	/	/	/
16	63.14	12.73	/	/	/	/	/	365.29	223.37	/	/	/	/	/
17	-5.17	-2.62	1.23	/	/	/	/	59.47	26.54	38.88	/	/	/	/
18	-4.93	0.17	-12.61	0.62	/	/	/	3.83	10.89	42.98	-37.95	/	/	/
19	98.84	/	/	/	/	/	/	240.18	/	/	/	/	/	/
20	-5.05	-2.99	3.15	5.20	/	/	/	46.98	7.08	9.98	23.40	/	/	/
21	50.61	15.88	/	/	/	/	/	107.29	114.49	/	/	/	/	/
22	72.16	/	/	/	/	/	/	364.29	/	/	/	/	/	/
23	54.54	/	/	/	/	/	/	136.79	/	/	/	/	/	/
24	59.50	/	/	/	/	/	/	348.62	/	/	/	/	/	/
25	52.94	22.41	28.27	/	/	/	/	56.65	-16.13	-49.03	/	/	/	/
26	51.79	15.96	/	/	/	/	/	84.04	101.37	/	/	/	/	/
27	97.23	/	/	/	/	/	/	395.21	/	/	/	/	/	/
28	51.34	27.53	/	/	/	/	/	187.77	208.65	/	/	/	/	/
29	-3.70	-6.51	-2.68	-6.80	/	/	/	67.90	33.18	46.59	-0.87	/	/	/
30	-5.54	-2.05	4.08	-6.42	/	/	/	33.59	25.79	-3.57	10.26	/	/	/
31	-4.53	-0.92	-4.01	2.45	/	/	/	-1.45	35.46	3.84	-54.22	/	/	/
32	-4.05	-4.90	0.11	-9.77	7.43	/	/	4.01	-18.83	-35.04	-16.08	-23.57	/	/
33	2.62	-6.69	-9.63	/	/	/	/	174.70	150.10	17.69	/	/	/	/
34	-5.10	-7.53	-21.42	-11.23	12.96	/	/	-10.53	-18.98	20.87	-36.38	-51.09	/	/
35	57.27	36.11	/	/	/	/	/	215.14	140.26	/	/	/	/	/
36	54.22	28.37	25.71	/	/	/	/	47.73	53.98	31.60	/	/	/	/
37	-6.43	-0.62	2.74	/	/	/	/	43.64	3.07	46.31	/	/	/	/
38	65.46	18.82	4.67	/	/	/	/	224.92	184.41	35.44	/	/	/	/
39	58.60	34.32	/	/	/	/	/	91.26	46.34	/	/	/	/	/
40	-5.95	-0.68	-9.77	/	/	/	/	43.88	4.04	163.20	/	/	/	/
41	73.98	26.24	/	/	/	/	/	291.31	272.54	/	/	/	/	/
42	-4.79	-2.05	1.41	9.02	/	/	/	11.67	16.21	12.24	-9.51	/	/	/
43	-8.17	-6.10	-0.92	-5.92	/	/	/	2.53	-29.40	-9.07	27.53	/	/	/
44	-6.18	-1.52	-4.49	-0.64	/	/	/	2.51	25.72	177.06	17.06	/	/	/
45	-3.70	-5.32	0.15	8.06	/	/	/	-3.54	-25.98	-20.88	-40.08	/	/	/
46	71.47	14.87	/	/	/	/	/	365.81	305.85	/	/	/	/	/
47	68.12	/	/	/	/	/	/	318.01	/	/	/	/	/	/
48	74.48	/	/	/	/	/	/	411.31	/	/	/	/	/	/
49	-5.52	-4.88	-5.22	6.06	/	/	/	61.19	35.38	76.36	-22.73	/	/	/
50	-2.49	0.30	0.13	/	/	/	/	-16.08	8.29	2.94	/	/	/	/
51	71.78	/	/	/	/	/	/	331.25	/	/	/	/	/	/
52	73.40	/	/	/	/	/	/	305.98	/	/	/	/	/	/
53	50.00	25.90	/	/	/	/	/	43.76	30.33	/	/	/	/	/
54	-5.68	16.49	7.99	/	/	/	/	-13.20	19.33	-14.20	/	/	/	/
55	-4.59	-0.11	-2.69	/	/	/	/	6.93	32.56	-8.14	/	/	/	/
56	-4.87	-1.41	9.36	13.10	/	/	/	3.01	17.76	-31.44	-52.37	/	/	/
57	50.72	24.76	/	/	/	/	/	147.45	221.04	/	/	/	/	/
58	98.28	/	/	/	/	/	/	123.46	/	/	/	/	/	/
59	-3.69	-5.42	-9.65	0.96	/	/	/	-14.16	-11.16	-32.36	-48.63	/	/	/
60	75.40	/	/	/	/	/	/	348.83	/	/	/	/	/	/
61	-6.21	-3.61	-0.34	7.32	/	/	/	-8.47	7.29	22.27	-8.75	/	/	/
62	66.81	/	/	/	/	/	/	343.79	/	/	/	/	/	/
63	-9.60	-6.14	-6.39	1.82	/	/	/	1.43	14.45	53.73	19.00	/	/	/
64	-5.83	-3.01	-2.06	1.42	/	/	/	-3.91	8.12	-21.69	-31.23	/	/	/
65	70.60	/	/	/	/	/	/	258.84	/	/	/	/	/	/
66	-6.75	-4.99	-2.77	/	/	/	/	15.36	-0.82	24.49	/	/	/	/
67	-7.93	-7.33	/	/	/	/	/	13.34	15.45	/	/	/	/	/
68	72.52	17.33	/	/	/	/	/	318.09	224.25	/	/	/	/	/
69	69.17	/	/	/	/	/	/	315.19	/	/	/	/	/	/
70	51.93	22.75	/	/	/	/	/	110.93	128.53	/	/	/	/	/
71	49.95	25.62	/	/	/	/	/	102.54	129.16	/	/	/	/	/
72	-4.99	-1.57	-10.44	-7.69	/	/	/	14.19	51.53	-14.03	-65.38	/	/	/
73	-6.05	-2.38	-0.76	8.15	/	/	/	14.71	15.01	41.53	-12.85	/	/	/
74	-5.64	-1.81	-0.57	3.15	/	/	/	7.91	20.39	-20.42	-19.38	/	/	/
75	-4.52	-2.57	-4.39	-12.37	/	/	/	49.71	11.05	52.32	-11.58	/	/	/
76	-6.83	-4.02	-1.81	-2.60	0.55	/	/	16.51	-8.82	-23.96	-5.13	-33.32	/	/
77	-6.24	-1.04	-1.08	/	/	/	/	-1.52	53.39	57.12	/	/	/	/
78	72.15	/	/	/	/	/	/	428.66	/	/	/	/	/	/
79	-8.78	-3.04	10.09	/	/	/	/	31.07	1.70	17.92	/	/	/	/
80	61.65	/	/	/	/	/	/	461.83	/	/	/	/	/	/
81	-3.25	-0.10	11.78	/	/	/	/	49.49	61.20	62.86	/	/	/	/
82	-6.97	-2.07	11.52	/	/	/	/	2.96	-7.59	53.08	/	/	/	/
83	53.19	18.64	21.78	/	/	/	/	54.53	222.69	82.23	/	/	/	/
84	68.46	/	/	/	/	/	/	145.01	/	/	/	/	/	/
85	69.56	/	/	/	/	/	/	269.83	/	/	/	/	/	/
86	71.27	/	/	/	/	/	/	229.18	/	/	/	/	/	/
87	-7.49	38.06	/	/	/	/	/	20.36	72.95	/	/	/	/	/
88	-6.99	-5.24	2.97	-12.81	/	/	/	55.90	-6.10	26.87	48.43	/	/	/
89	-6.98	-1.80	1.29	6.27	/	/	/	26.48	3.40	0.02	-9.16	/	/	/
90	70.16	/	/	/	/	/	/	315.63	/	/	/	/	/	/
91	48.68	/	/	/	/	/	/	51.41	/	/	/	/	/	/
92	-4.77	-2.88	9.42	/	/	/	/	52.33	30.18	33.67	/	/	/	/
93	54.11	28.86	17.36	/	/	/	/	25.78	36.00	28.78	/	/	/	/
94	83.98	/	/	/	/	/	/	195.45	/	/	/	/	/	/
95	64.74	/	/	/	/	/	/	302.13	/	/	/	/	/	/
96	-8.13	-1.43	-5.41	-1.39	/	/	/	-8.83	3.11	32.76	14.06	/	/	/
97	61.17	26.08	/	/	/	/	/	92.28	132.74	/	/	/	/	/
98	73.29	/	/	/	/	/	/	337.52	/	/	/	/	/	/
99	-0.85	4.83	-7.65	-0.70	/	/	/	110.67	99.21	185.35	31.01	/	/	/
100	-6.43	-5.30	7.63	0.07	/	/	/	3.66	2.07	80.70	24.68	/	/	/

Appendix Table B.4d Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 200 length measurements using the two partitions for grouping the Red mullet data.

	Sample size = 200 length measurements													
	% Bias													
	1 cm													
	mean 1	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*mean 7*	*SD 1*	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*	*SD 7*
1	-9.87	-37.86	-25.63	-31.51	-34.53	-37.13	/	-81.10	-84.82	-85.23	-92.45	-93.60	-95.53	/
2	-6.94	-39.16	-21.05	-28.51	-31.82	-34.58	-26.50	-50.37	-88.31	-92.77	-90.36	-93.24	-96.84	-96.05
3	-7.46	-32.10	-23.03	-28.53	-30.47	-27.17	-24.00	-82.87	-73.54	-92.20	-91.32	-92.72	-94.44	-94.10
4	-0.24	-35.47	-23.69	-6.26	/	/	/	-76.39	-84.01	-91.47	-90.09	/	/	/
5	-11.95	-42.32	-47.71	-50.86	-38.88	-40.97	-42.78	-79.26	-84.14	-91.47	-89.83	-93.60	-94.44	-96.05
6	-13.36	-40.91	-44.50	-39.22	-40.38	-41.26	-42.89	-83.20	-81.14	-92.62	-87.87	-89.71	-92.90	-95.37
7	-9.24	-38.41	-47.47	-33.40	-35.72	-36.34	-38.47	-77.39	-85.69	-86.20	-93.59	-90.94	-91.06	-94.41
8	-13.48	-42.41	-47.92	-38.98	-32.29	-25.89	/	-83.76	-86.34	-89.67	-86.68	-93.23	-96.45	/
9	-1.23	-34.28	-45.72	-38.79	-37.56	-38.55	-36.56	-84.97	-85.69	-89.31	-94.18	-94.79	-95.71	-94.41
10	-5.42	-38.81	-48.41	-33.26	-34.19	-36.48	-34.88	-82.87	-83.84	-94.35	-86.79	-93.27	-93.35	-96.05
11	-8.55	-32.97	-15.43	-10.57	-9.61	-12.86	/	-81.10	-85.02	-92.62	-92.15	-95.91	-91.06	/
12	-11.18	-37.71	-46.68	-32.82	-34.62	-36.11	-32.49	-65.87	-84.01	-87.16	-91.42	-91.02	-95.53	-96.05
13	4.35	-6.70	-23.21	-23.52	-16.96	-18.59	-13.94	1.34	-84.67	-92.91	-92.45	-93.60	-88.92	-93.98
14	-10.21	-40.32	-25.67	-25.84	-12.06	-9.24	/	-83.76	-85.69	-92.20	-91.42	-93.60	-88.95	/
15	-7.98	-39.69	-47.66	-33.60	-34.93	-38.44	-27.85	-83.20	-84.34	-85.64	-93.00	-91.82	-91.06	-93.43
16	-14.44	-42.62	-47.00	-35.15	-36.56	-34.29	-33.44	-70.68	-77.09	-89.71	-92.45	-94.56	-91.09	-91.17
17	-9.26	-38.62	-45.39	-36.89	-35.15	-33.69	-39.63	-82.28	-87.29	-88.27	-87.87	-89.21	-83.00	-93.72
18	-8.06	-36.56	-43.36	-31.66	-31.80	-28.52	/	-84.42	-82.94	-88.75	-91.42	-93.60	-94.16	/
19	-0.66	-34.98	-44.00	-31.28	-33.55	-34.07	-20.31	-54.70	-87.46	-87.59	-94.02	-93.24	-96.84	-92.23
20	-4.61	-35.83	-25.17	-30.22	-8.57	/	/	-85.24	-86.12	-81.92	-91.42	-88.70	/	/
21	-9.74	-37.12	-47.07	-33.98	-36.09	-37.90	/	-79.36	-82.34	-90.18	-91.42	-95.52	-93.68	/
22	-6.98	-37.38	-25.01	-30.79	-30.93	-21.39	/	-77.61	-82.94	-89.56	-94.72	-93.27	-88.83	/
23	-10.56	-39.36	-48.01	-51.66	-33.80	-36.11	-37.99	-83.32	-86.06	-77.76	-87.87	-91.02	-95.53	-95.56
24	-7.84	-36.67	-45.84	-29.18	-25.70	-20.01	/	-71.07	-86.30	-89.56	-89.80	-89.79	-94.84	/
25	-8.39	-39.34	-46.48	-33.07	-34.71	-36.35	-25.06	-73.12	-76.99	-94.14	-90.36	-88.70	-91.45	-95.83
26	-11.49	-33.03	-42.85	-35.15	-35.48	-35.34	-34.13	-84.69	-78.87	-91.71	-92.45	-92.72	-92.90	-92.10
27	-11.96	-36.92	-47.14	-27.83	-30.03	-18.73	-21.83	-71.35	-83.43	-94.78	-90.64	-92.72	-90.00	-91.62
28	-5.19	-38.77	-48.28	-52.82	-31.12	-9.58	/	-83.12	-81.14	-88.80	-84.38	-92.72	-90.19	/
29	-5.92	-36.30	-22.59	-29.10	-30.03	-27.42	/	-79.26	-87.62	-93.97	-87.87	-92.72	-96.84	/
30	-7.60	-38.25	-48.64	-28.17	-28.40	-31.51	-26.23	-86.32	-84.63	-87.12	-93.59	-93.60	-95.53	-95.08
31	-5.92	-37.19	-46.15	-30.38	-31.87	-33.81	-35.84	-83.76	-85.97	-93.10	-89.91	-87.45	-94.84	-93.16
32	-5.63	-34.99	-18.40	-25.84	-12.85	-15.16	/	-75.00	-77.13	-91.90	-91.21	-90.94	-95.53	/
33	-8.30	-40.53	-48.06	-29.20	-17.65	/	/	-77.61	-85.02	-89.56	-92.88	-95.06	/	/
34	-9.49	-34.34	-20.60	-27.34	-13.15	/	/	-82.87	-80.65	-93.97	-90.36	-92.72	/	/
35	-8.29	-35.39	-44.64	-36.02	-28.94	-14.26	-15.09	-81.17	-74.84	-90.31	-95.71	-93.60	-90.40	-93.98
36	-9.87	-39.56	-44.47	-36.46	-35.66	/	/	-75.87	-84.25	-89.98	-92.45	-85.54	/	/
37	-11.18	-36.67	-47.64	-31.85	-31.08	-32.79	-35.12	-81.54	-45.33	-89.29	-95.05	-90.12	-93.68	-92.10
38	-12.73	-39.64	-48.70	-50.27	-22.95	-26.28	-25.83	-69.74	-85.47	-90.82	-92.45	-92.72	-95.71	-91.33
39	-5.92	-38.03	-45.95	-29.58	-30.03	-11.72	/	-81.54	-92.62	-89.31	-90.36	-94.85	-83.00	/
40	-12.05	-39.91	-46.30	-33.11	-34.16	-36.03	-26.50	-77.43	-78.87	-89.85	-86.44	-88.70	-96.35	-94.41
41	-8.33	-35.67	-45.49	-24.99	-14.93	-4.25	/	-86.95	-85.44	-90.82	-91.76	-95.06	-93.19	/
42	-6.61	-35.70	-22.37	-29.91	-32.75	-32.04	-27.22	-63.73	-37.15	-90.82	-93.19	-93.60	-93.93	-97.21
43	-8.48	-41.52	-48.44	-34.90	-34.23	-36.32	-23.63	-73.90	-79.52	-87.92	-91.44	-93.24	-92.67	-94.41
44	-6.74	-38.65	-48.64	-52.52	-51.54	-41.65	-40.25	-77.38	-88.74	-90.54	-94.47	-94.85	-93.68	-94.81
45	-11.18	-38.07	-43.62	-36.40	-36.82	-38.92	-37.99	-87.89	-85.57	-87.42	-90.76	-93.01	-94.84	-94.41
46	-8.71	-39.88	-44.45	-33.98	-32.75	-33.81	-36.80	-85.34	-88.04	-88.27	-87.87	-90.41	-93.68	-96.05
47	-12.50	-39.63	-47.71	-33.98	-35.48	-14.90	/	-87.22	-79.60	-89.79	-93.59	-91.82	-91.06	/
48	-10.16	-38.94	-48.13	-36.31	-35.48	-37.13	-39.56	-81.83	-88.47	-90.31	-87.87	-92.72	-95.53	-96.21
49	-13.82	-42.16	-51.26	-50.85	-32.61	-34.59	-18.60	-85.68	-85.69	-83.39	-93.34	-93.60	-89.96	-96.05
50	-5.65	-36.76	-47.42	-52.60	-39.83	-38.46	-36.33	-81.68	-88.17	-91.77	-89.45	-89.71	-94.26	-91.12
51	-10.69	-39.64	-44.00	-33.74	-34.39	-28.70	-26.98	-69.59	-88.80	-90.82	-90.36	-92.72	-93.68	-95.09
52	-2.78	-33.86	-43.04	-30.85	-18.87	-13.82	/	-63.98	-86.66	-91.22	-83.77	-94.85	-90.79	/
53	0.90	-33.05	-22.22	-26.54	-19.14	-22.82	-24.75	-62.78	-89.11	-82.33	-93.34	-94.56	-96.84	-96.77
54	-10.03	-39.77	-26.00	-31.69	-33.86	-23.89	-18.12	-85.34	-87.73	-94.14	-84.49	-87.03	-90.19	-97.21
55	-1.71	-36.46	-46.81	-25.26	-12.99	/	/	-77.62	-84.01	-89.31	-91.42	-88.95	/	/
56	-6.20	-37.24	-26.99	-30.76	-32.75	-33.81	-36.80	-83.46	-68.33	-90.82	-86.56	-94.56	-93.68	-96.05
57	-8.30	-36.75	-44.83	-32.40	-35.18	-35.34	-38.11	-78.30	-87.86	-89.56	-94.18	-93.01	-93.68	-96.81
58	-9.87	-35.01	-25.01	-29.61	-32.88	-34.56	-28.63	-84.69	-74.20	-88.27	-91.42	-92.19	-93.93	-93.05
59	-3.29	-35.39	-46.20	-31.32	-33.65	-17.46	/	-75.80	-84.82	-84.60	-90.36	-93.27	-91.06	/
60	-7.12	-37.01	-45.77	-31.25	-33.30	-31.43	/	-68.63	-81.89	-91.65	-91.21	-91.82	-96.35	/
61	-4.22	-34.54	-25.67	-27.59	-30.58	/	/	-84.93	-82.12	-85.23	-94.47	-94.56	/	/
62	-10.09	-40.84	-46.72	-31.66	-34.59	-34.32	-37.03	-88.12	-86.76	-86.24	-91.21	-89.99	-94.44	-94.41
63	-13.91	-39.09	-47.47	-52.40	-33.52	-28.44	-23.87	-81.32	-82.35	-88.80	-92.19	-92.16	-96.45	-96.86
64	-11.93	-40.45	-18.86	-27.18	/	/	/	-72.21	-88.17	-81.55	-92.79	/	/	/
65	-9.87	-38.93	-45.49	-21.50	/	/	/	-75.68	-87.35	-93.10	-91.76	/	/	/
66	-2.02	-27.78	-21.27	-26.76	-13.79	/	/	-68.50	-81.97	-93.97	-91.44	-95.32	/	/
67	-12.26	-42.26	-50.19	-54.49	-36.42	-36.49	/	-78.96	-88.02	-92.67	-91.55	-93.34	-89.05	/
68	-14.17	-37.68	-47.31	-34.28	-35.98	-36.11	-12.62	-87.47	-84.41	-90.92	-86.44	-91.02	-95.53	-94.41
69	-15.79	-39.87	-46.16	-29.91	-29.49	-27.93	-30.57	-89.63	-82.56	-87.62	-93.86	-93.60	-90.00	-96.05
70	-3.65	-31.47	-23.20	-26.26	-24.04	-23.59	-20.28	-68.30	-87.86	-78.81	-92.04	-89.71	-94.44	-94.41
71	-10.93	-37.16	-44.17	-29.55	-29.38	-7.49	/	-78.30	-54.96	-92.20	-91.90	-92.72	-90.00	/
72	-18.42	-34.32	-23.78	-30.49	-22.99	-25.38	-28.25	-86.95	-72.60	-83.13	-91.42	-89.88	-96.84	-94.83
73	-7.64	-38.43	-24.57	-28.57	-31.35	-24.10	/	-90.80	-70.52	-91.47	-87.58	-91.82	-93.68	
74	-11.95	-39.59	-48.16	/	/	/	/	-79.26	-89.43	-89.72	/	/	/	/
75	-1.17	-36.48	-46.18	-32.59	-24.45	/	/	-82.28	-91.28	-83.97	-92.18	-89.29	/	/
76	-9.57	-39.01	-48.90	-28.56	-31.94	-24.78	-24.11	-80.19	-86.89	-83.86	-91.42	-95.91	-94.84	-95.09
77	-15.13	-37.22	-46.98	-33.98	-36.02	-37.64	-38.95	-83.76	-90.38	-89.67	-93.59	-94.56	-96.45	-94.41
78	-15.13	-40.78	-49.05	-34.25	-36.84	-33.56	-26.98	-75.87	-82.49	-85.64	-92.04	-94.85	-94.16	-92.10
79	-4.43	-36.64	-47.36	-50.54	-41.71	-40.24	-42.78	-88.35	-89.98	-80.04	-92.04	-90.94	-92.90	-92.69
80	-2.79	-33.30	-27.11	-30.79	-31.73	-32.07	-30.33	-70.47	-86.34	-93.28	-95.18	-87.64	-90.19	-94.41
81	-9.87	-39.15	-43.18	-33.40	-29.15	-24.23	-27.70	-86.21	-82.64	-94.14	-93.34	-96.44	-94.44	-96.05
82	-10.43	-39.66	-47.62	-50.71	-37.38	-36.07	-34.64	-82.87	-85.46	-89.07	-90.36	-96.36	-92.90	-95.09
83	-12.16	-42.95	-48.75	-49.76	-40.25	-42.24	-42.78	-67.98	-76.90	-89.56	-89.07	-92.16	-95.53	-94.41
84	-7.24	-34.41	-45.05	-32.24	-33.94	-32.50	-32.73	-79.26	-85.69	-93.97	-92.45	-95.32	-94.15	-95.09
85	-5.75	-35.34	-44.57	-16.54	-19.68	-9.53	/	-65.50	-89.11	-88.80	-87.87	-94.22	-95.53	/
86	-2.91	-29.88	-21.56	-18.47	-14.56	/	/	-55.43	-87.67	-89.02	-88.93	-88.70	/	/
87	-13.82	-41.47	-48.49	-32.43	-32.30	-31.90	-26.82	-81.54	-85.79	-84.10	-95.05	-92.16	-95.71	-94.41
88	-9.53	-40.78	-48.13	-35.30	-30.56	/	/	-83.76	-87.80	-91.07	-94.18	-90.16	/	/
89	-14.17	-37.49	-45.49	-31.21	-33.69	-20.94	/	-87.47	-72.52	-91.47	-92.76	-93.24	-95.12	/
90	6.15	-3.34	-17.24	-19.31	-19.56	-22.06	/	-78.44	-92.30	-88.98	-90.76	-92.16	-91.06	/
91	-9.19	-40.33	-28.63	-33.16	-34.26	-36.07	-38.12	-83.76	-70.71	-83.41	-90.36	-92.16	-92.73	-96.21
92	-10.38	-41.66	-50.65	-35.34	-30.76	-32.28	-32.89	-80.19	-83.59	-86.35	-95.05	-92.72	-93.68	-96.77
93	-9.60	-38.84	-48.03	-33.47	-33.84	-35.86	-37.99	-67.01	-85.97	-89.02	-84.59	-93.60	-94.98	-95.44
94	-12.50	-42.11	-24.65	-30.93	-33.78	-25.26	-24.35	-84.93	-92.30	-86.40	-92.45	-92.13	-95.71	-96.86
95	-8.48	-37.10	-46.39	-33.63	-15.58	/	/	-71.55	-85.38	-91.28	-91.13	-93.01	/	/
96	-7.51	-39.24	-49.08	-50.81	-40.38	-41.48	-39.11	-77.30	-85.97	-89.74	-89.42	-92.72	-93.68	-96.77
97	-10.93	-29.82	-27.98	-30.36	-29.36	-8.77	/	-85.83	-47.37	-92.62	-90.76	-80.43	-91.06	/
98	-12.50	-39.21	-43.76	-35.73	-36.17	-36.88	-39.00	-83.76	-84.82	-90.14	-91.42	-95.06	-92.90	-89.96
99	-5.92	-38.54	-47.98	-31.24	-33.65	-33.81	-33.20	-81.10	-89.41	-89.21	-92.04	-93.27	-93.68	-92.10
100	-9.87	-41.22	-50.21	-35.96	-35.35	-37.39	-24.59	-83.76	-93.33	-79.32	-87.28	-90.84	-91.73	-94.41

Appendix Table B.5a Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 500 length measurements using the two partitions for grouping the Red mullet data.

Sample size = 500 length measurements														
Estimates														
Birgè and Rozenholc algorithm														
	mean 1 *(cm)*	*mean 2* *(cm)*	*mean 3* *(cm)*	*mean 4* *(cm)*	*mean 5* *(cm)*	*mean 6* *(cm)*	*mean 7* *(cm)*	*SD 1* *(cm)*	*SD 2* *(cm)*	*SD 3* *(cm)*	*SD 4* *(cm)*	*SD 5* *(cm)*	*SD 6* *(cm)*	*SD 7* *(cm)*
1	7.36	11.65	12.19	16.26	18.33	21.36	/	0.55	0.74	1.08	1.23	0.56	0.92	/
2	7.15	11.92	15.01	17.59	21.23	/	/	0.67	0.94	2.25	0.97	0.51	/	/
3	7.06	11.68	18.40	/	/	/	/	0.74	1.02	1.20	/	/	/	/
4	7.00	11.87	14.51	18.21	/	/	/	0.68	1.13	2.32	1.99	/	/	/
5	7.16	11.40	11.69	18.26	20.50	/	/	0.63	0.71	1.18	0.70	0.49	/	/
6	7.23	11.64	17.57	19.19	/	/	/	0.61	0.78	1.04	0.86	/	/	/
7	7.22	11.47	12.05	14.76	16.40	/	/	0.66	0.98	1.41	1.35	2.11	/	/
8	11.58	16.06	/	/	/	/	/	0.95	1.70	/	/	/	/	/
9	7.24	11.75	18.50	/	/	/	/	0.61	0.90	1.53	/	/	/	/
10	7.06	11.78	13.45	17.16	/	/	/	0.70	1.06	3.18	1.78	/	/	/
11	7.15	12.01	15.97	17.96	/	/	/	0.70	0.80	1.10	1.18	/	/	/
12	7.31	11.28	11.45	13.88	15.79	18.19	20.07	0.71	0.51	0.89	0.92	1.10	0.50	0.31
13	6.92	11.92	19.50	/	/	/	/	0.75	1.32	1.02	/	/	/	/
14	7.21	11.67	13.76	17.11	/	/	/	0.76	0.96	2.50	1.31	/	/	/
15	7.26	12.18	15.86	18.09	21.72	/	/	0.61	0.87	1.62	0.95	0.93	/	/
16	7.19	11.86	15.84	16.87	/	/	/	0.68	0.70	1.94	1.12	/	/	/
17	7.24	11.65	12.21	15.73	16.58	18.12	/	0.66	0.69	0.98	1.77	2.23	1.28	/
18	7.06	11.60	15.24	/	/	/	/	0.70	0.90	2.17	/	/	/	/
19	7.21	11.74	14.10	17.73	/	/	/	0.91	1.01	3.29	2.02	/	/	/
20	7.11	11.53	13.84	18.10	/	/	/	0.61	0.96	4.33	1.00	/	/	/
21	7.16	11.72	14.50	16.78	18.64	/	/	0.64	1.04	0.83	0.78	0.76	/	/
22	7.10	11.81	14.70	18.43	/	/	/	0.75	0.92	1.08	1.29	/	/	/
23	7.25	11.63	16.31	16.88	/	/	/	0.78	1.10	1.46	1.85	/	/	/
24	7.34	12.10	12.00	15.62	18.20	21.59	/	0.62	0.89	1.25	1.17	0.72	0.34	/
25	7.22	11.63	18.06	/	/	/	/	0.62	0.82	0.95	/	/	/	/
26	7.02	12.08	13.73	/	/	/	/	0.86	1.13	4.28	/	/	/	/
27	7.33	11.85	15.97	/	/	/	/	0.66	0.95	1.89	/	/	/	/
28	7.09	12.12	19.50	/	/	/	/	0.69	1.23	1.10	/	/	/	/
29	7.32	13.68	14.73	18.94	/	/	/	0.62	1.57	0.81	0.76	/	/	/
30	7.16	11.41	14.29	19.06	/	/	/	0.71	0.88	2.19	1.35	/	/	/
31	7.23	11.61	15.55	19.60	/	/	/	0.70	0.70	1.65	0.77	/	/	/
32	7.15	11.48	15.00	16.05	19.32	/	/	0.69	0.86	1.19	2.11	1.30	/	/
33	7.00	12.08	15.44	18.18	/	/	/	0.75	1.19	1.39	1.35	/	/	/
34	7.54	11.81	15.52	16.90	18.93	/	/	0.71	0.81	0.88	0.79	0.89	/	/
35	7.31	11.78	15.29	17.64	/	/	/	0.63	0.90	2.55	1.77	/	/	/
36	7.29	11.97	14.66	17.16	17.90	21.05	/	0.71	0.90	1.58	1.44	1.55	0.83	/
37	7.07	11.58	15.55	17.41	/	/	/	0.71	0.77	2.38	1.00	/	/	/
38	7.16	11.81	17.87	/	/	/	/	0.64	1.01	1.36	/	/	/	/
39	7.21	11.72	15.22	18.47	/	/	/	0.60	0.95	2.33	1.82	/	/	/
40	7.27	11.67	14.27	16.99	18.97	/	/	0.73	0.93	1.06	1.63	1.23	/	/
41	7.30	11.88	16.33	17.02	/	/	/	0.66	1.15	1.60	1.28	/	/	/
42	7.14	12.24	15.36	16.82	/	/	/	0.75	1.39	1.78	1.76	/	/	/
43	7.23	12.44	15.59	17.13	/	/	/	0.62	1.01	0.98	1.65	/	/	/
44	7.08	11.63	15.39	16.40	18.98	/	/	0.66	1.03	1.12	2.75	1.15	/	/
45	12.32	14.85	/	/	/	/	/	1.63	2.54	/	/	/	/	/
46	7.23	11.76	15.24	17.76	/	/	/	0.63	0.86	1.19	1.38	/	/	/
47	7.34	12.07	14.77	16.84	18.74	20.13	/	0.64	0.43	0.56	1.00	0.44	0.42	/
48	7.27	11.59	14.67	16.72	/	/	/	0.69	0.81	2.29	1.17	/	/	/
49	7.33	11.82	15.84	/	/	/	/	0.63	0.97	1.12	/	/	/	/
50	7.35	14.08	16.46	20.80	/	/	/	0.54	1.64	0.83	0.32	/	/	/
51	7.23	11.80	15.99	18.53	/	/	/	0.68	0.72	1.33	0.72	/	/	/
52	7.39	11.38	17.23	19.66	/	/	/	0.61	0.64	1.06	1.09	/	/	/
53	7.02	11.69	15.03	/	/	/	/	0.69	1.02	2.30	/	/	/	/
54	7.14	11.76	14.81	/	/	/	/	0.68	0.78	1.26	/	/	/	/
55	7.29	11.74	15.36	18.02	/	/	/	0.61	0.84	1.35	0.81	/	/	/
56	7.30	11.10	14.62	/	/	/	/	0.65	0.62	1.12	/	/	/	/
57	7.01	11.51	15.29	21.45	/	/	/	0.88	0.77	1.58	1.25	/	/	/
58	7.22	11.87	15.66	18.04	19.82	/	/	0.59	1.04	0.83	0.97	0.88	/	/
59	7.23	11.86	14.71	18.61	19.98	/	/	0.63	0.93	0.83	1.39	1.11	/	/
60	7.27	11.79	14.51	17.89	/	/	/	0.69	1.10	1.30	1.43	/	/	/
61	7.26	11.35	11.66	15.42	19.67	/	/	0.57	0.72	1.14	2.03	0.84	/	/
62	7.21	11.72	14.66	17.49	19.86	/	/	0.73	0.73	1.10	0.85	0.94	/	/
63	7.19	11.70	14.92	15.44	19.23	/	/	0.62	0.99	1.27	1.11	0.85	/	/
64	7.13	11.57	15.15	16.00	19.65	/	/	0.66	0.84	1.60	1.65	0.98	/	/
65	6.98	11.65	15.13	16.80	20.58	/	/	0.79	0.78	2.08	1.32	0.56	/	/
66	7.15	11.83	16.70	21.09	/	/	/	0.65	1.18	1.14	1.01	/	/	/
67	7.28	11.75	15.84	16.03	18.69	/	/	0.71	0.72	1.77	0.83	0.85	/	/
68	7.08	12.02	15.74	17.30	/	/	/	0.72	1.14	1.71	1.35	/	/	/
69	7.22	11.59	18.12	22.32	/	/	/	0.65	0.62	1.03	0.85	/	/	/
70	7.35	11.83	15.92	19.68	/	/	/	0.66	0.90	1.33	0.71	/	/	/
71	7.26	12.02	13.97	15.97	18.65	/	/	0.62	1.01	1.25	0.56	0.83	/	/
72	7.26	11.43	15.45	16.86	18.81	/	/	0.67	0.97	0.79	1.38	0.93	/	/
73	7.25	12.02	15.08	16.63	18.23	19.85	/	0.53	0.82	0.91	0.61	0.51	/	/
74	7.11	11.77	14.16	21.71	/	/	/	0.72	0.96	1.45	0.58	/	/	/
75	7.25	11.65	15.30	18.05	/	/	/	0.60	0.80	1.35	0.70	/	/	/
76	7.09	11.74	15.10	/	/	/	/	0.70	0.91	1.26	/	/	/	/
77	7.20	11.88	14.75	17.10	20.69	/	/	0.64	0.78	1.34	0.96	0.91	/	/
78	7.32	11.79	12.23	14.95	17.06	17.53	19.94	0.60	0.92	1.44	0.92	0.91	0.88	0.82
79	7.12	11.88	15.48	18.38	/	/	/	0.95	1.12	1.37	0.93	/	/	/
80	7.10	12.21	15.93	17.24	/	/	/	0.78	1.20	2.58	2.04	/	/	/
81	7.20	12.11	14.77	17.38	18.75	/	/	0.73	1.17	1.12	1.11	1.27	/	/
82	7.25	11.73	15.92	16.84	20.36	/	/	0.64	0.85	1.94	1.33	0.73	/	/
83	7.34	11.81	15.65	17.82	19.56	21.15	/	0.64	0.60	0.54	0.39	0.38	0.47	/
84	7.04	12.12	17.20	/	/	/	/	0.77	1.06	1.24	/	/	/	/
85	7.20	11.39	17.62	/	/	/	/	0.68	0.81	1.51	/	/	/	/
86	7.14	12.02	18.02	/	/	/	/	0.71	1.06	0.95	/	/	/	/
87	7.37	11.44	12.11	14.98	18.02	21.39	/	0.63	0.61	0.82	0.92	0.71	0.64	/
88	7.17	11.75	14.51	16.73	/	/	/	0.60	0.97	2.18	1.21	/	/	/
89	7.20	11.52	14.19	17.26	18.39	/	/	0.64	0.72	1.03	1.58	0.97	/	/
90	7.17	11.80	18.83	/	/	/	/	0.58	0.79	1.26	/	/	/	/
91	7.19	11.37	12.15	13.33	16.26	18.62	19.27	0.60	0.64	1.21	3.50	2.93	0.98	0.92
92	7.14	11.77	15.43	20.86	/	/	/	0.71	0.93	1.72	1.25	/	/	/
93	7.10	11.59	15.21	18.79	/	/	/	0.72	0.85	3.02	1.24	/	/	/
94	7.08	11.79	14.55	16.05	17.68	/	/	0.59	0.85	2.26	1.16	1.75	/	/
95	7.23	12.27	15.79	/	/	/	/	0.77	1.56	1.41	/	/	/	/
96	7.32	12.05	11.75	15.38	17.34	19.99	/	0.71	1.11	0.83	1.60	1.12	1.01	/
97	7.10	12.02	/	/	/	/	/	0.89	0.98	/	/	/	/	/
98	7.27	11.61	12.06	15.44	18.93	/	/	0.70	0.61	1.08	1.69	1.29	/	/
99	7.24	11.66	15.95	/	/	/	/	0.74	0.75	1.70	/	/	/	/
100	7.16	11.68	15.16	/	/	/	/	0.70	0.89	1.38	/	/	/	/

Appendix Table B.5b Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 500 length measurements using the two partitions for grouping the Red mullet data.

	Sample size = 500 length measurements													
	Estimates													
	1 cm													
	mean 1 (cm)	*mean 2 (cm)*	*mean 3 (cm)*	*mean 4 (cm)*	*mean 5 (cm)*	*mean 6 (cm)*	*mean 7 (cm)*	*SD 1 (cm)*	*SD 2 (cm)*	*SD 3 (cm)*	*SD 4 (cm)*	*SD 5 (cm)*	*SD 6 (cm)*	*SD 7 (cm)*
1	6.54	7.33	7.56	10.71	11.25	11.67	11.96	0.15	0.25	0.46	0.06	0.11	0.13	0.15
2	6.75	7.57	8.29	11.02	11.45	11.71	12.20	0.18	0.12	0.14	0.08	0.13	0.13	0.22
3	6.20	6.63	7.62	8.36	10.61	11.03	11.50	0.07	0.10	0.14	0.10	0.06	0.12	0.18
4	6.21	6.87	7.70	8.39	10.97	11.39	12.00	0.11	0.13	0.16	0.15	0.10	0.45	0.25
5	6.79	7.17	8.19	11.23	11.40	11.75	12.19	0.27	0.15	0.11	0.10	0.08	0.18	0.11
6	6.81	7.29	8.14	11.15	11.71	12.01	12.30	0.00	0.10	0.29	0.12	0.11	0.18	0.07
7	6.35	7.03	7.86	8.52	10.47	11.09	11.53	0.10	0.16	0.32	0.15	0.13	0.10	0.14
8	6.94	7.34	8.05	10.65	11.15	11.60	11.84	0.22	0.18	0.23	0.10	0.11	0.22	0.16
9	6.81	7.48	10.75	11.11	11.32	11.68	12.19	0.21	0.36	0.11	0.11	0.09	0.08	0.16
10	6.45	7.04	7.48	8.13	11.29	11.57	12.42	0.15	0.25	0.40	0.14	0.21	0.19	0.12
11	6.96	6.72	7.66	11.00	11.46	12.11	12.61	0.47	0.14	0.41	0.08	0.17	0.09	0.10
12	6.77	7.61	8.38	11.51	12.00	12.44	15.87	0.10	0.14	0.15	0.11	0.19	0.17	0.42
13	6.29	6.77	7.44	8.12	10.30	10.78	11.65	0.11	0.25	0.15	0.17	0.19	0.11	0.36
14	6.41	6.80	7.21	8.24	8.83	10.32	10.80	0.19	0.11	0.12	0.13	0.09	0.16	0.07
15	6.78	7.03	7.76	8.32	11.58	12.07	12.51	0.19	0.21	0.25	0.13	0.09	0.12	0.12
16	6.67	7.35	7.96	11.54	11.86	13.15	13.73	0.12	0.13	0.15	0.08	0.16	0.11	0.19
17	6.66	7.11	7.53	8.47	9.15	11.16	11.75	0.15	0.20	0.16	0.11	0.12	0.35	0.10
18	6.89	7.46	8.17	8.88	10.81	11.68	12.09	0.15	0.46	0.20	0.14	0.07	0.14	0.15
19	6.54	7.17	7.67	8.62	10.73	11.32	11.89	0.13	0.20	0.56	0.11	0.15	0.16	0.14
20	6.61	6.92	7.71	7.82	10.94	11.55	11.83	0.14	0.14	0.32	0.28	0.16	0.14	0.14
21	6.91	7.31	7.81	8.64	10.75	11.11	11.67	0.31	0.34	0.13	0.14	0.09	0.13	0.12
22	6.35	7.33	7.88	8.65	11.33	12.04	12.32	0.10	0.35	0.22	0.11	0.14	0.10	0.07
23	6.50	6.91	7.70	8.51	10.55	11.02	11.45	0.10	0.20	0.26	0.20	0.12	0.09	0.12
24	6.76	7.13	7.72	8.58	10.74	11.48	12.35	0.09	0.11	0.25	0.18	0.17	0.12	0.10
25	6.70	7.06	7.51	8.38	11.02	11.62	12.29	0.10	0.15	0.23	0.11	0.11	0.10	0.19
26	6.56	7.22	11.42	12.69	13.01	13.86	14.25	0.11	0.19	0.11	0.12	0.10	0.13	0.09
27	6.59	6.89	8.07	8.40	10.55	10.85	11.28	0.09	0.16	0.17	0.10	0.10	0.12	0.16
28	6.85	7.25	7.76	8.49	10.50	11.05	11.55	0.12	0.18	0.16	0.14	0.08	0.13	0.12
29	7.17	7.78	8.32	10.94	11.61	12.32	15.23	0.36	0.22	0.16	0.17	0.11	0.15	0.18
30	6.75	7.47	7.93	8.90	10.60	11.22	11.74	0.14	0.13	0.12	0.08	0.19	0.12	0.15
31	6.86	7.20	7.70	8.43	10.78	11.39	11.84	0.14	0.18	0.11	0.15	0.18	0.10	0.27
32	6.15	6.79	7.79	8.61	10.87	11.19	11.58	0.10	0.15	0.26	0.10	0.09	0.10	0.09
33	6.29	7.37	7.74	8.65	11.49	11.81	12.35	0.13	0.17	0.21	0.09	0.14	0.17	0.17
34	7.39	7.77	8.39	10.78	11.01	11.38	11.84	0.22	0.15	0.10	0.21	0.07	0.13	0.14
35	6.30	6.95	7.87	8.59	11.03	12.02	12.49	0.08	0.27	0.20	0.11	0.14	0.11	0.16
36	6.31	7.14	7.99	8.91	11.32	11.68	12.07	0.06	0.15	0.30	0.08	0.10	0.09	0.11
37	6.65	7.27	8.10	8.85	10.62	11.13	12.35	0.24	0.31	0.12	0.13	0.12	0.09	0.10
38	7.24	7.85	8.29	11.63	11.95	12.24	12.65	0.14	0.23	0.12	0.13	0.16	0.17	0.09
39	6.79	7.29	7.76	10.83	11.72	12.20	12.65	0.10	0.22	0.24	0.10	0.08	0.13	0.14
40	6.70	7.11	7.82	8.75	11.33	11.76	12.60	0.12	0.14	0.15	0.08	0.13	0.17	0.13
41	6.73	7.07	7.56	8.19	10.85	11.17	11.49	0.21	0.25	0.23	0.23	0.16	0.13	0.16
42	6.59	7.40	8.35	10.45	11.01	12.82	13.54	0.23	0.37	0.13	0.12	0.13	0.11	0.10
43	7.03	7.91	8.37	11.05	11.75	12.08	12.38	0.23	0.13	0.16	0.12	0.09	0.11	0.15
44	6.64	7.22	7.95	11.12	11.60	11.92	12.24	0.11	0.16	0.21	0.12	0.17	0.13	0.10
45	6.48	7.40	7.90	8.32	11.15	11.44	11.81	0.10	0.31	0.31	0.19	0.12	0.09	0.18
46	7.54	8.14	8.76	11.02	12.81	14.45	14.90	0.50	0.13	0.15	0.11	0.69	0.37	0.39
47	6.88	7.81	8.29	10.45	10.75	11.71	12.42	0.09	0.15	0.13	0.11	0.11	0.15	0.12
48	6.53	7.42	8.58	10.55	11.05	12.37	13.20	0.06	0.16	0.11	0.12	0.10	0.09	0.05
49	6.48	7.47	8.05	8.67	10.50	10.92	11.13	0.12	0.45	0.15	0.10	0.07	0.14	0.11
50	6.35	6.85	8.16	11.63	12.11	12.42	13.18	0.17	0.14	0.51	0.12	0.14	0.11	0.22
51	6.35	7.22	7.65	11.16	11.92	12.70	13.36	0.22	0.21	0.14	0.18	0.15	0.20	0.17
52	6.69	6.98	7.71	10.44	11.62	11.95	12.61	0.17	0.14	0.19	0.17	0.13	0.10	0.20
53	6.39	6.80	7.27	7.82	11.02	11.45	11.90	0.12	0.09	0.18	0.31	0.06	0.12	0.12
54	6.62	7.05	7.77	10.87	11.23	12.49	12.97	0.27	0.32	0.19	0.11	0.08	0.09	0.09
55	6.02	6.76	8.25	7.85	12.31	12.69	13.12	0.08	0.16	1.06	0.20	0.58	0.22	0.11
56	6.73	7.30	8.03	11.08	11.88	13.45	14.63	0.12	0.12	0.15	0.11	0.22	0.22	0.13
57	6.99	7.49	8.31	10.82	11.12	11.53	12.33	0.15	0.18	0.11	0.20	0.18	0.09	0.14
58	6.70	7.30	7.58	12.07	12.56	13.01	13.92	0.18	0.22	0.50	0.27	0.09	0.07	0.10
59	6.51	7.72	8.25	11.12	11.62	11.91	12.86	0.07	1.45	0.23	0.11	0.12	0.07	0.36
60	6.99	7.38	7.83	11.00	11.95	12.49	12.80	0.19	0.22	0.11	0.11	0.10	0.24	0.15
61	6.45	6.97	7.53	8.29	10.45	11.18	11.71	0.12	0.11	0.21	0.11	0.16	0.13	0.13
62	5.95	8.14	8.45	11.05	11.61	12.04	13.12	0.11	0.51	0.22	0.12	0.11	0.16	0.14
63	6.83	7.24	7.62	8.26	10.66	11.15	12.00	0.13	0.14	0.18	0.14	0.17	0.11	0.16
64	6.29	6.69	7.40	8.76	10.80	11.82	12.48	0.11	0.23	0.40	0.20	0.15	0.20	0.15
65	6.28	6.80	7.83	8.71	11.19	11.58	12.34	0.15	0.16	0.12	0.14	0.17	0.20	0.10
66	6.91	7.74	8.16	11.15	11.49	11.93	12.45	0.08	0.26	0.20	0.08	0.10	0.09	0.14
67	6.29	6.83	7.86	10.72	11.09	11.57	12.08	0.13	0.17	0.18	0.11	0.11	0.09	0.14
68	6.47	6.76	7.29	7.64	11.13	11.83	13.01	0.11	0.10	0.17	0.48	0.12	0.11	0.09
69	6.63	6.98	7.77	8.44	11.74	12.71	13.08	0.16	0.12	0.21	0.16	0.14	0.10	0.09
70	6.31	7.44	8.22	10.45	11.14	11.61	11.84	0.12	0.21	0.28	0.20	0.14	0.10	0.14
71	6.64	7.08	7.77	8.30	10.89	12.02	12.46	0.10	0.12	0.13	0.10	0.11	0.11	0.17
72	6.45	6.81	7.74	10.75	11.12	11.47	12.26	0.10	0.11	0.13	0.09	0.12	0.11	0.18
73	6.63	7.19	7.92	8.31	10.55	11.48	12.48	0.10	0.23	0.10	0.15	0.11	0.11	0.14
74	6.05	6.60	7.26	8.23	8.80	11.36	12.82	0.12	0.15	0.23	0.15	0.06	0.16	0.14
75	6.62	7.33	7.79	8.73	10.95	11.88	12.24	0.16	0.23	0.16	0.13	0.14	0.13	0.12
76	6.39	6.87	7.70	12.39	14.25	14.79	15.15	0.10	0.12	0.18	0.68	0.09	0.11	0.16
77	6.46	6.73	7.60	9.00	11.00	11.35	12.11	0.15	0.07	0.54	0.07	0.12	0.13	0.12
78	6.99	7.24	7.53	8.23	10.75	11.00	11.39	0.13	0.32	0.58	0.32	0.10	0.05	0.11
79	6.70	7.28	7.88	11.29	11.72	12.13	12.41	0.10	0.19	0.29	0.17	0.13	0.11	0.06
80	6.56	6.93	7.38	11.65	12.40	13.57	15.47	0.14	0.15	0.26	0.22	0.26	0.13	0.09
81	6.79	7.05	7.38	10.63	11.63	11.94	12.25	0.19	0.15	0.15	0.20	0.09	0.11	0.16
82	6.92	7.42	7.88	8.76	10.90	11.50	12.03	0.21	0.13	0.29	0.15	0.12	0.16	0.15
83	7.12	8.28	8.70	11.62	11.93	12.71	13.07	0.44	0.12	0.12	0.21	0.24	0.10	0.10
84	6.48	6.88	7.60	8.21	11.05	11.99	12.29	0.13	0.23	0.12	0.12	0.11	0.12	0.12
85	6.96	7.39	7.88	8.54	10.66	11.26	12.04	0.14	0.21	0.12	0.13	0.17	0.19	0.22
86	6.44	7.48	7.77	8.70	10.73	11.53	11.94	0.07	0.32	0.39	0.12	0.08	0.11	0.14
87	6.55	6.96	7.68	8.70	10.91	11.67	12.37	0.13	0.18	0.24	0.20	0.13	0.12	0.12
88	6.61	7.01	7.67	8.39	10.51	11.33	11.89	0.20	0.12	0.26	0.20	0.13	0.07	0.21
89	6.35	6.80	7.54	7.90	11.20	11.65	12.26	0.16	0.17	0.30	0.22	0.11	0.12	0.12
90	6.67	6.99	7.55	11.49	12.13	12.48	12.95	0.09	0.14	0.14	0.16	0.12	0.11	0.19
91	6.84	7.44	8.16	9.10	10.60	11.61	12.05	0.15	0.20	0.11	0.08	0.15	0.12	0.18
92	6.40	7.42	8.57	11.50	13.05	13.61	14.60	0.15	0.55	0.10	0.20	0.10	0.13	0.12
93	6.20	7.32	7.78	8.58	11.25	11.67	12.15	0.11	0.35	0.17	0.12	0.10	0.16	0.14
94	6.81	7.62	8.14	11.43	11.75	12.06	12.56	0.30	0.18	0.16	0.09	0.13	0.13	0.10
95	6.35	7.19	7.83	11.00	11.50	11.98	13.12	0.13	0.14	0.12	0.12	0.12	0.12	0.25
96	6.49	7.40	7.73	8.24	10.72	11.31	12.12	0.22	0.19	0.26	0.15	0.14	0.11	0.44
97	6.37	7.95	8.33	11.88	12.37	13.29	14.17	0.09	0.66	0.16	0.50	0.13	0.20	0.14
98	7.37	7.71	8.01	8.58	10.87	11.17	11.87	0.20	0.18	0.10	0.22	0.09	0.13	0.11
99	6.74	7.30	7.89	8.26	11.50	11.95	12.31	0.33	0.19	0.19	0.22	0.19	0.14	0.09
100	6.56	7.36	11.25	11.99	12.53	13.57	13.92	0.10	0.14	0.11	0.19	0.10	0.14	0.12

Appendix Table B.5c Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 500 length measurements using the two partitions for grouping the Red mullet data.

Sample size = 500 length measurements														
% Bias														
Birgè and Rozenholc algorithm														
	mean 1	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*mean 7*	*SD 1*	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*	*SD 7*
1	-3.19	-3.85	-19.47	-5.45	-0.21	9.15	/	-15.12	-18.23	-6.46	-12.38	-66.31	-51.43	/
2	-5.98	-1.70	-0.84	2.34	15.62	/	/	3.01	4.64	95.47	-30.71	-69.30	/	/
3	-7.10	-3.63	21.56	/	/	/	/	13.90	13.09	4.20	/	/	/	/
4	-7.83	-2.10	-4.11	5.92	/	/	/	5.24	25.17	101.96	42.30	/	/	/
5	-5.81	-5.98	-22.76	6.23	11.61	/	/	-3.87	-21.06	2.46	-50.26	-70.30	/	/
6	-4.91	-3.97	16.11	11.62	/	/	/	-6.77	-13.69	-9.86	-38.80	/	/	/
7	-5.02	-5.35	-20.37	-14.16	-10.70	/	/	0.96	8.71	22.88	-3.58	28.06	/	/
8	52.38	32.50	/	/	/	/	/	46.32	88.83	/	/	/	/	/
9	-4.77	-3.06	22.26	/	/	/	/	-5.65	0.16	33.21	/	/	/	/
10	-7.09	-2.86	-11.17	-0.22	/	/	/	8.16	17.61	176.46	26.92	/	/	/
11	-5.93	-0.91	5.54	4.48	/	/	/	7.03	-11.65	-4.41	-15.70	/	/	/
12	-3.86	-6.93	-24.32	-19.29	-14.00	-7.02	-3.92	9.54	-43.61	-22.72	-34.29	-33.10	-73.67	-85.67
13	-8.96	-1.68	28.86	/	/	/	/	14.87	46.18	-11.50	/	/	/	/
14	-5.09	-3.73	-9.10	-0.51	/	/	/	17.18	6.93	116.90	-6.62	/	/	/
15	-4.42	0.48	4.76	5.23	18.27	/	/	-6.98	-3.80	40.91	-32.18	-43.79	/	/
16	-5.45	-2.19	4.65	-1.88	/	/	/	4.98	-21.75	69.01	-20.13	/	/	/
17	-4.73	-3.92	-19.31	-8.49	-9.71	-7.38	/	1.55	-23.60	-14.76	26.68	35.29	-32.86	/
18	-7.13	-4.31	0.70	/	/	/	/	8.09	0.07	88.34	/	/	/	/
19	-5.13	-3.13	-6.86	3.14	/	/	/	39.16	11.85	185.87	44.55	/	/	/
20	-6.47	-4.84	-8.53	5.27	/	/	/	-6.65	6.94	276.59	-28.86	/	/	/
21	-5.74	-3.27	-4.17	-2.39	1.50	/	/	-1.81	15.16	-27.93	-43.97	-54.07	/	/
22	-6.57	-2.55	-2.90	7.19	/	/	/	14.67	2.38	-6.09	-7.55	/	/	/
23	-4.64	-4.01	7.78	-1.83	/	/	/	19.66	21.83	27.28	32.14	/	/	/
24	-3.42	-0.19	-20.74	-9.16	-0.89	10.34	/	-5.27	-1.44	8.80	-16.12	-56.21	-81.94	/
25	-5.03	-4.03	19.33	/	/	/	/	-4.65	-8.82	-17.23	/	/	/	/
26	-7.66	-0.33	-9.27	/	/	/	/	32.39	25.41	271.91	/	/	/	/
27	-3.51	-2.26	5.50	/	/	/	/	1.12	5.23	64.41	/	/	/	/
28	-6.75	0.01	28.83	/	/	/	/	6.12	36.29	-3.97	/	/	/	/
29	-3.63	12.89	-2.65	10.17	/	/	/	-5.45	73.89	-29.41	-45.39	/	/	/
30	-5.82	-5.83	-5.56	10.88	/	/	/	8.70	-2.54	90.07	-3.27	/	/	/
31	-4.90	-4.21	2.71	14.02	/	/	/	6.89	-22.46	43.62	-44.76	/	/	/
32	-5.91	-5.31	-0.92	-6.65	5.18	/	/	6.63	-4.96	3.69	50.41	-21.37	/	/
33	-7.90	-0.32	2.05	5.73	/	/	/	14.59	31.79	20.67	-3.80	/	/	/
34	-0.75	-2.60	2.55	-1.73	3.05	/	/	8.59	-9.82	-23.59	-43.29	-45.78	/	/
35	-3.86	-2.84	1.05	2.58	/	/	/	-3.30	-0.14	121.39	26.60	/	/	/
36	-4.11	-1.26	-3.15	-0.18	-2.52	7.56	/	9.14	-0.20	37.46	2.92	-6.31	-56.51	/
37	-7.03	-4.51	2.77	1.25	/	/	/	9.23	-14.02	106.96	-28.26	/	/	/
38	-5.83	-2.57	18.09	/	/	/	/	-1.12	12.47	17.99	/	/	/	/
39	-5.11	-3.27	0.59	7.45	/	/	/	-7.61	5.80	102.70	30.19	/	/	/
40	-4.32	-3.73	-5.68	-1.17	3.27	/	/	12.17	3.79	-7.67	16.48	-25.45	/	/
41	-3.92	-2.00	7.87	-1.00	/	/	/	0.69	28.10	38.89	-8.47	/	/	/
42	-6.03	1.02	1.49	-2.19	/	/	/	15.18	53.96	54.35	25.77	/	/	/
43	-4.93	2.66	2.99	-0.35	/	/	/	-5.38	12.44	-14.44	17.88	/	/	/
44	-6.90	-4.08	1.70	-4.59	3.34	/	/	1.10	14.07	-3.07	96.37	-30.19	/	/
45	62.14	22.50	/	/	/	/	/	150.22	182.20	/	/	/	/	/
46	-4.82	-2.97	0.70	3.30	/	/	/	-3.66	-4.27	3.68	-1.44	/	/	/
47	-3.37	-0.41	-2.41	-2.03	2.03	2.87	/	-2.41	-52.69	-51.13	-28.63	-73.56	-77.66	/
48	-4.30	-4.40	-3.04	-2.73	/	/	/	6.62	-10.16	99.18	-16.28	/	/	/
49	-3.57	-2.50	4.65	/	/	/	/	-3.46	7.39	-2.70	/	/	/	/
50	-3.28	16.15	8.78	20.97	/	/	/	-17.75	81.59	-27.79	-77.46	/	/	/
51	-4.84	-2.69	5.67	7.80	/	/	/	4.00	-20.30	15.67	-48.91	/	/	/
52	-2.73	-6.15	13.87	14.36	/	/	/	-5.50	-28.90	-7.49	-21.84	/	/	/
53	-7.59	-3.54	-0.70	/	/	/	/	5.46	12.89	99.93	/	/	/	/
54	-6.12	-2.97	-2.16	/	/	/	/	5.19	-13.84	9.10	/	/	/	/
55	-4.14	-3.19	1.49	4.81	/	/	/	-6.80	-7.02	17.61	-42.16	/	/	/
56	-3.97	-8.44	-3.40	/	/	/	/	-0.42	-31.31	-2.75	/	/	/	/
57	-7.81	-5.01	1.05	24.76	/	/	/	34.73	-14.70	36.92	-10.90	/	/	/
58	-4.97	-2.09	3.49	4.91	7.91	/	/	-10.08	15.34	-27.90	-30.69	-46.55	/	/
59	-4.87	-2.16	-2.82	8.24	8.80	/	/	-3.60	3.02	-28.15	-0.45	-32.58	/	/
60	-4.32	-2.73	-4.11	4.03	/	/	/	5.27	22.62	13.01	2.22	/	/	/
61	-4.48	-6.36	-22.93	-10.33	7.13	/	/	-12.91	-20.05	-0.91	44.99	-48.81	/	/
62	-5.18	-3.35	-3.12	1.75	8.16	/	/	11.81	-18.99	-4.60	-39.32	-42.89	/	/
63	-5.38	-3.49	-1.44	-10.18	4.70	/	/	-4.06	10.26	10.40	-20.78	-48.45	/	/
64	-6.16	-4.58	0.09	-6.93	7.01	/	/	1.30	-6.48	39.00	17.50	-40.85	/	/
65	-8.20	-3.92	-0.05	-2.29	12.08	/	/	21.11	-13.83	81.14	-5.48	-66.00	/	/
66	-5.96	-2.39	10.32	22.69	/	/	/	-0.18	31.34	-0.73	-28.12	/	/	/
67	-4.20	-3.05	4.64	-6.76	1.78	/	/	9.20	-20.30	53.99	-40.67	-48.51	/	/
68	-6.83	-0.81	4.01	0.64	/	/	/	11.21	26.12	49.02	-3.48	/	/	/
69	-5.06	-4.37	19.72	29.82	/	/	/	0.27	-30.85	-10.43	-38.98	/	/	/
70	-3.31	-2.42	5.18	14.48	/	/	/	0.89	-0.24	15.86	-49.17	/	/	/
71	-4.42	-0.87	-7.71	-7.08	1.57	/	/	-4.67	11.69	8.26	-59.68	-49.47	/	/
72	-4.47	-5.67	2.09	-1.91	2.42	/	/	2.87	8.14	-31.25	-1.13	-43.50	/	/
73	-4.63	-0.81	-0.39	-3.26	-0.74	1.43	/	-19.22	-9.41	-20.92	-56.19	-68.98	/	/
74	-6.40	-2.87	-6.46	26.25	/	/	/	10.33	6.43	26.42	-58.84	/	/	/
75	-4.64	-3.88	1.07	4.96	/	/	/	-8.47	-11.62	17.38	-50.14	/	/	/
76	-6.69	-3.14	-0.24	/	/	/	/	7.66	0.81	9.61	/	/	/	/
77	-5.27	-2.02	-2.53	-0.52	12.66	/	/	-1.23	-13.28	16.42	-31.18	-45.08	/	/
78	-3.75	-2.75	-19.20	-13.03	-7.13	-10.38	-4.51	-8.04	2.07	25.50	-33.96	-44.72	-53.46	-61.73
79	-6.33	-1.99	2.28	6.91	/	/	/	45.80	23.85	18.81	-33.60	/	/	/
80	-6.54	0.74	5.26	0.29	/	/	/	20.37	33.45	124.13	45.46	/	/	/
81	-5.22	-0.06	-2.44	1.11	2.08	/	/	12.08	30.42	-2.85	-21.00	-22.84	/	/
82	-4.63	-3.21	5.18	-2.07	10.89	/	/	-1.65	-5.35	68.24	-4.74	-55.48	/	/
83	-3.37	-2.60	3.41	3.66	6.51	8.11	/	-1.05	-33.31	-52.84	-71.95	-76.72	-75.11	/
84	-7.35	-0.01	13.65	/	/	/	/	17.60	17.17	7.56	/	/	/	/
85	-5.27	-6.00	16.45	/	/	/	/	5.19	-10.45	30.92	/	/	/	/
86	-5.99	-0.82	19.04	/	/	/	/	8.66	17.45	-17.42	/	/	/	/
87	-3.01	-5.60	-19.96	-12.86	-1.89	9.33	/	-3.25	-32.00	-28.51	-34.63	-56.92	-66.56	/
88	-5.69	-3.02	-4.11	-2.67	/	/	/	-8.15	7.62	89.69	-13.34	/	/	/
89	-5.22	-4.95	-6.24	0.41	0.15	/	/	-1.69	-19.98	-10.61	12.94	-40.97	/	/
90	-5.61	-2.65	24.40	/	/	/	/	-10.69	-12.37	9.93	/	/	/	/
91	-5.44	-6.19	-19.71	-22.49	-11.46	-4.85	-7.72	-7.51	-29.13	5.24	149.97	77.46	-48.68	-57.33
92	-6.02	-2.86	1.96	21.30	/	/	/	9.01	3.34	49.51	-10.89	/	/	/
93	-6.56	-4.37	0.50	9.31	/	/	/	10.02	-5.40	162.46	-11.36	/	/	/
94	-6.83	-2.73	-3.90	-6.65	-3.75	/	/	-9.38	-5.31	96.11	-17.30	5.79	/	/
95	-4.88	1.21	4.32	/	/	/	/	18.16	72.82	22.43	/	/	/	/
96	-3.75	-0.59	-22.34	-10.57	-5.59	2.18	/	9.76	23.55	-27.51	14.34	-32.05	-46.75	/
97	-6.51	-0.81	/	/	/	/	/	37.45	9.34	/	/	/	/	/
98	-4.35	-4.22	-20.34	-10.18	3.09	/	/	7.92	-32.44	-5.93	20.64	-22.07	/	/
99	-4.74	-3.81	5.40	/	/	/	/	14.27	-16.59	48.21	/	/	/	/
100	-5.77	-3.63	0.13	/	/	/	/	8.26	-1.66	20.18	/	/	/	/

Appendix Table B.5d Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 500 length measurements using the two partitions for grouping the Red mullet data.

Sample size = 500 length measurements														
% Bias														
1 cm														
	mean 1	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*mean 7*	*SD 1*	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*	*SD 7*
1	-13.92	-39.54	-50.02	-37.70	-38.74	-40.36	-42.72	-77.11	-72.58	-59.78	-95.80	-93.24	-93.18	-92.85
2	-11.13	-37.55	-45.23	-35.89	-37.65	-40.16	-41.57	-71.65	-87.14	-88.01	-94.18	-91.90	-92.90	-89.76
3	-18.42	-45.34	-49.64	-51.38	-42.22	-43.62	-44.95	-88.65	-88.64	-87.40	-92.84	-96.61	-93.68	-91.77
4	-18.26	-43.32	-49.12	-51.20	-40.25	-41.76	-42.54	-82.56	-85.21	-85.92	-89.38	-93.96	-76.23	-88.45
5	-10.66	-40.86	-45.88	-34.71	-37.93	-39.94	-41.63	-58.14	-83.73	-90.58	-92.54	-94.85	-90.61	-95.09
6	-10.35	-39.83	-46.24	-35.15	-36.21	-38.64	-41.10	-100.00	-89.41	-75.00	-91.49	-93.42	-90.68	-96.69
7	-16.45	-42.00	-48.09	-50.45	-43.01	-43.32	-44.79	-85.34	-82.73	-72.04	-89.45	-91.82	-94.60	-93.36
8	-8.64	-39.47	-46.82	-38.06	-39.29	-40.70	-43.30	-65.94	-79.57	-79.66	-93.19	-93.24	-88.42	-92.34
9	-10.44	-38.30	-28.97	-35.40	-38.37	-40.29	-41.61	-67.76	-59.57	-90.82	-92.44	-94.35	-95.62	-92.50
10	-15.08	-41.96	-50.56	-52.71	-38.53	-40.88	-40.53	-77.55	-72.75	-65.34	-89.96	-87.39	-89.84	-94.28
11	-8.48	-44.54	-49.37	-36.02	-37.62	-38.12	-39.60	-28.43	-84.01	-64.21	-93.93	-89.71	-95.29	-95.37
12	-10.95	-37.24	-44.65	-33.03	-34.66	-36.41	-24.03	-84.18	-84.05	-86.54	-92.22	-88.78	-91.17	-80.31
13	-17.26	-44.17	-50.86	-52.79	-43.92	-44.92	-44.21	-83.86	-71.86	-87.16	-87.87	-88.49	-94.44	-83.37
14	-15.70	-43.87	-52.37	-52.08	-51.91	-47.27	-48.29	-70.98	-87.93	-89.98	-90.98	-94.56	-91.84	-96.86
15	-10.84	-41.99	-48.76	-51.61	-36.94	-38.29	-40.08	-70.31	-77.20	-78.11	-90.89	-94.35	-93.88	-94.54
16	-12.19	-39.36	-47.44	-32.89	-35.40	-32.79	-34.24	-81.86	-85.34	-86.78	-93.98	-90.35	-94.44	-90.98
17	-12.33	-41.35	-50.26	-50.72	-50.18	-42.95	-43.74	-77.61	-78.08	-86.22	-91.86	-92.72	-81.46	-95.44
18	-9.33	-38.43	-46.03	-48.35	-41.13	-40.32	-42.10	-76.39	-49.33	-82.85	-89.76	-95.47	-92.62	-93.16
19	-13.89	-40.82	-49.30	-49.84	-41.60	-42.14	-43.06	-79.93	-78.04	-51.60	-92.45	-90.99	-91.73	-93.36
20	-13.05	-42.92	-49.05	-54.51	-40.41	-40.97	-43.35	-79.02	-84.16	-71.76	-80.01	-90.43	-92.42	-93.64
21	-9.02	-39.67	-48.39	-49.77	-41.47	-43.21	-44.14	-52.74	-62.39	-88.83	-89.92	-94.79	-93.22	-94.44
22	-16.45	-39.53	-47.92	-49.69	-38.29	-38.48	-41.01	-84.69	-61.41	-80.55	-92.45	-91.35	-94.66	-96.54
23	-14.42	-43.03	-49.15	-50.52	-42.55	-43.68	-45.18	-85.30	-77.98	-77.31	-85.87	-92.72	-95.09	-94.63
24	-11.03	-41.21	-48.98	-50.12	-41.50	-41.30	-40.87	-85.92	-87.54	-78.07	-87.26	-89.88	-93.53	-95.22
25	-11.82	-41.78	-50.35	-51.25	-40.02	-40.61	-41.17	-85.07	-83.81	-80.26	-91.94	-93.38	-94.70	-91.22
26	-13.66	-40.44	-24.56	-26.17	-29.13	-29.15	-31.77	-82.87	-78.80	-90.74	-91.42	-94.06	-93.17	-95.83
27	-13.27	-43.13	-46.65	-51.14	-42.55	-44.54	-45.98	-85.60	-82.56	-85.23	-92.59	-94.22	-93.68	-92.74
28	-9.87	-40.18	-48.76	-50.62	-42.83	-43.52	-44.70	-82.03	-79.47	-86.10	-90.05	-94.85	-93.22	-94.28
29	-5.71	-35.78	-45.00	-36.34	-36.81	-37.02	-27.09	-45.18	-75.13	-86.24	-87.87	-93.34	-92.35	-91.55
30	-11.18	-38.34	-47.59	-48.23	-42.29	-42.66	-43.80	-78.87	-85.27	-89.27	-93.93	-88.44	-93.86	-92.97
31	-9.73	-40.63	-49.12	-50.98	-41.28	-41.79	-43.32	-78.69	-79.53	-90.36	-89.03	-88.95	-94.60	-87.33
32	-19.08	-44.02	-48.56	-49.91	-40.82	-42.80	-44.55	-85.34	-83.36	-77.21	-92.67	-94.38	-94.54	-95.72
33	-17.21	-39.22	-48.89	-49.69	-37.43	-39.62	-40.88	-79.26	-81.02	-81.79	-93.59	-91.35	-91.31	-92.19
34	-2.79	-35.88	-44.59	-37.29	-40.04	-41.86	-43.32	-66.35	-83.75	-91.40	-84.85	-95.47	-93.29	-93.62
35	-17.11	-42.67	-47.98	-50.02	-39.97	-38.56	-40.18	-86.95	-69.75	-82.94	-92.04	-91.39	-94.13	-92.78
36	-16.92	-41.09	-47.22	-48.15	-38.38	-40.29	-42.22	-90.33	-82.94	-74.13	-94.02	-94.06	-95.09	-94.70
37	-12.51	-40.03	-46.50	-48.53	-42.19	-43.11	-40.87	-62.42	-65.47	-89.98	-90.36	-92.72	-95.09	-95.53
38	-4.67	-35.24	-45.25	-32.36	-34.93	-37.46	-39.43	-78.00	-73.99	-89.42	-90.73	-90.48	-91.27	-95.71
39	-10.60	-39.89	-48.76	-37.03	-36.16	-37.63	-39.43	-84.93	-75.90	-79.25	-92.88	-94.96	-93.40	-93.30
40	-11.80	-41.34	-48.33	-49.11	-38.32	-39.88	-39.65	-81.54	-84.14	-87.10	-94.21	-92.19	-91.19	-94.07
41	-11.51	-41.63	-50.08	-52.36	-40.92	-42.90	-44.96	-68.03	-72.49	-80.40	-83.87	-90.48	-93.22	-92.44
42	-13.33	-38.95	-44.83	-39.22	-40.05	-34.45	-35.19	-64.61	-58.68	-88.80	-91.42	-92.19	-94.44	-95.39
43	-7.54	-34.78	-44.71	-35.73	-36.02	-38.27	-40.71	-64.50	-85.50	-85.73	-91.21	-94.41	-94.22	-92.82
44	-12.66	-40.45	-47.46	-35.35	-36.84	-39.07	-41.41	-82.49	-82.39	-81.51	-91.21	-89.71	-93.10	-95.22
45	-14.69	-38.94	-47.83	-51.61	-39.29	-41.55	-43.44	-85.34	-65.97	-73.41	-86.50	-92.55	-95.35	-91.42
46	-0.82	-32.83	-42.14	-35.91	-30.23	-26.15	-28.68	-23.06	-85.02	-87.12	-91.94	-58.34	-80.66	-81.69
47	-9.44	-35.54	-45.23	-39.22	-41.47	-40.13	-40.51	-86.43	-83.31	-88.27	-92.45	-93.60	-92.21	-94.27
48	-14.14	-38.80	-43.30	-38.64	-39.83	-36.78	-36.80	-90.77	-82.07	-90.18	-91.42	-94.06	-95.28	-97.54
49	-14.69	-38.37	-46.81	-49.57	-42.83	-44.16	-46.68	-81.54	-50.33	-86.60	-93.19	-95.91	-92.48	-95.05
50	-16.46	-43.49	-46.11	-32.38	-34.05	-36.50	-36.90	-74.55	-84.01	-55.91	-91.48	-91.22	-94.34	-89.67
51	-16.42	-40.41	-49.46	-35.11	-35.12	-35.11	-36.05	-66.04	-76.69	-87.55	-86.91	-91.07	-89.29	-92.10
52	-11.99	-42.38	-49.08	-39.25	-36.72	-38.92	-39.61	-73.90	-84.14	-83.76	-87.87	-92.05	-94.80	-90.80
53	-15.95	-43.88	-51.94	-54.51	-40.00	-41.48	-43.02	-81.32	-89.65	-84.50	-77.68	-96.37	-93.68	-94.33
54	-12.92	-41.84	-48.67	-36.76	-38.84	-36.17	-37.90	-58.20	-64.94	-83.76	-92.06	-95.32	-95.15	-95.83
55	-20.75	-44.23	-45.47	-54.32	-32.99	-35.16	-37.16	-87.47	-82.01	-8.29	-85.79	-64.94	-88.31	-95.09
56	-11.47	-39.78	-46.95	-35.58	-35.30	-31.26	-29.93	-81.68	-86.52	-87.16	-92.45	-86.75	-88.31	-93.88
57	-8.01	-38.21	-45.10	-37.08	-39.43	-41.07	-40.97	-77.57	-79.49	-90.82	-86.02	-89.03	-95.07	-93.52
58	-11.90	-39.80	-49.90	-29.83	-31.61	-33.51	-33.36	-72.55	-75.29	-56.49	-81.07	-94.56	-96.37	-95.44
59	-14.37	-36.32	-45.52	-35.35	-36.76	-39.12	-38.45	-88.88	61.10	-80.27	-92.19	-92.55	-96.07	-83.09
60	-8.02	-39.12	-48.29	-36.01	-34.93	-36.14	-38.73	-71.47	-75.28	-90.31	-92.45	-94.06	-87.42	-92.85
61	-15.13	-42.52	-50.28	-51.78	-43.10	-42.84	-43.95	-81.10	-87.62	-81.65	-91.86	-90.48	-92.90	-93.72
62	-21.71	-32.85	-44.17	-35.73	-36.77	-38.47	-37.16	-83.76	-43.39	-80.97	-91.76	-93.47	-91.58	-93.55
63	-10.12	-40.26	-49.65	-51.93	-41.94	-43.01	-42.56	-79.85	-84.03	-84.38	-90.05	-89.40	-94.44	-92.62
64	-17.30	-44.81	-51.13	-49.05	-41.18	-39.58	-40.24	-82.93	-74.16	-64.93	-85.42	-90.90	-89.50	-92.97
65	-17.37	-43.91	-48.29	-49.35	-39.07	-40.80	-40.91	-77.30	-81.96	-89.74	-89.80	-89.71	-89.67	-95.22
66	-9.08	-36.14	-46.09	-35.15	-37.46	-39.02	-40.39	-87.04	-71.55	-82.93	-94.06	-94.06	-95.28	-93.36
67	-17.21	-43.64	-48.07	-37.64	-39.61	-40.88	-42.14	-79.26	-81.63	-84.71	-92.04	-93.60	-95.48	-93.52
68	-14.91	-44.23	-51.85	-55.57	-39.41	-39.51	-37.70	-82.87	-88.52	-85.65	-66.06	-92.72	-94.39	-95.71
69	-12.74	-42.45	-48.66	-50.89	-36.10	-35.05	-37.36	-75.05	-86.98	-81.71	-88.73	-91.67	-94.95	-95.66
70	-16.96	-38.63	-45.67	-39.22	-39.36	-40.68	-43.33	-80.92	-76.50	-75.53	-85.65	-91.45	-94.66	-93.40
71	-12.67	-41.57	-48.68	-51.70	-40.68	-38.56	-40.36	-84.93	-87.02	-89.07	-92.88	-93.38	-94.13	-92.10
72	-15.13	-43.83	-48.83	-37.47	-39.48	-41.40	-41.30	-84.93	-87.47	-89.12	-93.34	-92.55	-94.25	-91.63
73	-12.77	-40.68	-47.66	-51.65	-42.55	-41.33	-40.22	-84.01	-74.33	-91.19	-89.61	-93.60	-94.13	-93.36
74	-20.39	-45.55	-52.03	-52.14	-52.08	-41.94	-38.63	-81.54	-83.59	-80.08	-89.55	-96.62	-91.47	-93.36
75	-12.87	-39.51	-48.53	-49.25	-40.38	-39.30	-41.39	-75.75	-73.91	-86.30	-90.36	-91.35	-92.90	-94.64
76	-15.95	-43.32	-49.15	-27.95	-22.41	-24.43	-27.46	-84.42	-86.40	-84.11	-51.31	-94.35	-94.16	-92.69
77	-15.03	-44.50	-49.77	-47.65	-40.09	-41.99	-41.99	-77.39	-91.70	-53.17	-95.18	-92.72	-93.01	-94.23
78	-8.05	-40.24	-50.23	-52.13	-41.47	-43.78	-45.46	-79.85	-64.11	-49.63	-76.91	-94.06	-97.22	-95.09
79	-11.78	-39.97	-47.95	-34.34	-36.18	-38.01	-40.60	-85.34	-79.10	-75.11	-87.87	-92.05	-94.06	-97.05
80	-13.66	-42.81	-51.26	-32.26	-32.49	-30.63	-25.93	-79.02	-83.60	-77.22	-84.62	-84.31	-93.22	-95.83
81	-10.71	-41.84	-51.22	-38.16	-36.67	-38.99	-41.34	-71.39	-83.17	-87.14	-85.58	-94.32	-94.00	-92.64
82	-8.98	-38.81	-47.94	-49.07	-40.63	-41.21	-42.38	-66.96	-85.21	-74.53	-89.42	-92.72	-91.73	-93.01
83	-6.27	-31.72	-42.54	-32.40	-35.06	-35.06	-37.40	-32.20	-86.56	-89.56	-85.27	-85.69	-94.84	-95.37
84	-14.79	-43.23	-49.76	-52.27	-39.83	-38.70	-41.16	-79.26	-74.54	-89.14	-91.18	-93.60	-93.68	-94.34
85	-8.36	-39.03	-47.91	-50.35	-41.98	-42.47	-42.36	-78.87	-76.52	-89.36	-90.53	-89.74	-90.26	-89.96
86	-15.23	-38.29	-48.64	-49.38	-41.56	-41.05	-42.85	-89.40	-64.11	-66.40	-91.76	-95.32	-94.13	-93.52
87	-13.82	-42.55	-49.26	-49.38	-40.61	-40.33	-40.75	-79.60	-80.42	-78.87	-85.45	-91.82	-93.79	-94.51
88	-12.99	-42.18	-49.29	-51.21	-42.78	-42.08	-43.05	-69.59	-87.03	-77.57	-85.96	-91.82	-96.45	-90.34
89	-16.45	-43.90	-50.17	-54.03	-38.99	-40.43	-41.28	-75.87	-81.67	-73.59	-84.33	-93.24	-93.53	-94.41
90	-12.25	-42.35	-50.12	-33.16	-33.95	-36.23	-37.99	-86.03	-84.18	-87.42	-88.41	-92.72	-94.22	-91.33
91	-10.05	-38.61	-46.06	-47.07	-42.28	-40.65	-42.30	-76.39	-77.34	-90.31	-93.93	-91.07	-93.69	-91.70
92	-15.80	-38.82	-43.35	-33.11	-28.94	-30.45	-30.11	-76.85	-39.47	-90.92	-85.64	-93.67	-92.90	-94.64
93	-18.42	-39.58	-48.58	-50.10	-38.74	-40.36	-41.80	-82.93	-61.56	-85.16	-91.08	-94.22	-91.59	-93.43
94	-10.42	-37.14	-46.25	-33.52	-36.02	-38.35	-39.84	-54.56	-80.06	-85.75	-93.31	-91.90	-93.19	-95.22
95	-16.45	-40.65	-48.26	-36.00	-37.39	-38.74	-37.17	-79.26	-84.68	-89.70	-91.42	-92.83	-93.53	-88.56
96	-14.65	-38.93	-48.91	-52.10	-41.65	-42.21	-41.99	-65.59	-78.46	-77.77	-89.21	-91.59	-94.13	-79.75
97	-16.18	-34.44	-44.96	-30.89	-32.62	-32.09	-32.14	-85.68	-26.86	-85.73	-63.96	-92.00	-89.51	-93.40
98	-3.06	-36.38	-47.10	-50.12	-40.83	-42.89	-43.19	-68.61	-79.52	-91.51	-84.27	-94.72	-92.90	-95.09
99	-11.35	-39.74	-47.88	-51.97	-37.40	-38.92	-41.04	-49.86	-78.46	-83.63	-84.14	-88.63	-92.64	-95.86
100	-13.63	-39.31	-25.67	-30.25	-31.79	-30.65	-33.36	-84.22	-84.88	-90.82	-86.24	-94.03	-92.57	-94.41

Appendix Table B.6a Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 1000 length measurements using the two partitions for grouping the Red mullet data.

Sample size = 1000 length measurements														
Estimates														
Birgè and Rozenholc algorithm														
	mean 1 (cm)	*mean 2 (cm)*	*mean 3 (cm)*	*mean 4 (cm)*	*mean 5 (cm)*	*mean 6 (cm)*	*mean 7 (cm)*	*SD 1 (cm)*	*SD 2 (cm)*	*SD 3 (cm)*	*SD 4 (cm)*	*SD 5 (cm)*	*SD 6 (cm)*	*SD 7 (cm)*
1	7.17	12.87	15.39	17.83	/	/	/	0.62	1.25	1.53	0.97	/	/	/
2	7.18	11.81	15.09	15.83	18.30	/	/	0.65	0.89	1.68	2.47	1.80	/	/
3	7.38	11.32	15.88	18.12	19.75	/	/	0.65	0.70	0.86	1.46	1.10	/	/
4	7.19	11.67	15.59	19.24	22.35	/	/	0.55	0.76	1.54	0.53	0.53	/	/
5	7.28	12.17	14.27	16.91	17.43	20.03	/	0.68	1.01	2.13	1.81	1.71	1.11	/
6	7.24	11.35	14.31	17.24	19.44	/	/	0.65	0.68	2.97	1.04	1.90	/	/
7	7.33	11.91	15.33	18.75	19.68	20.55	/	0.61	0.90	2.07	0.86	1.58	1.18	/
8	7.20	11.68	15.40	16.69	/	/	/	0.60	1.07	1.63	2.46	/	/	/
9	7.13	11.78	15.67	17.04	/	/	/	0.76	0.94	2.51	1.03	/	/	/
10	7.29	11.11	12.13	15.39	16.73	18.83	20.82	0.62	0.65	1.16	1.81	1.03	0.62	0.60
11	7.35	11.49	14.75	17.06	21.77	/	/	0.63	0.52	0.83	0.82	0.52	/	/
12	7.28	11.62	15.08	16.01	18.28	19.62	/	0.64	0.84	1.17	0.84	0.72	1.11	/
13	7.17	12.04	15.19	16.63	/	/	/	0.70	1.13	2.43	2.46	/	/	/
14	7.28	11.71	15.03	16.14	20.28	22.94	/	0.63	0.90	1.42	1.86	0.70	0.84	/
15	7.29	11.08	11.82	17.01	17.92	/	/	0.70	0.66	1.37	1.31	1.27	/	/
16	7.23	12.02	14.77	16.64	19.68	/	/	0.69	0.94	2.22	1.02	1.05	/	/
17	7.20	12.11	14.92	17.69	/	/	/	0.66	1.05	1.10	1.10	/	/	/
18	7.52	11.61	13.17	15.01	16.34	17.03	19.00	0.59	0.71	0.62	1.14	1.02	0.73	0.62
19	7.28	11.57	15.40	/	/	/	/	0.62	0.91	2.76	/	/	/	/
20	7.21	11.00	12.37	15.35	17.74	18.11	/	0.61	0.54	1.58	0.97	1.16	0.99	/
21	7.34	12.09	15.68	17.11	21.24	/	/	0.69	0.83	0.97	1.67	0.92	/	/
22	7.33	11.67	15.24	17.07	/	/	/	0.66	0.83	0.79	0.81	/	/	/
23	7.34	11.20	11.91	15.45	19.61	/	/	0.68	0.70	0.98	1.05	0.98	/	/
24	7.37	11.85	13.34	15.30	19.33	20.49	/	0.63	0.69	1.07	0.75	1.04	0.67	/
25	7.35	12.27	15.54	17.53	21.45	/	/	0.68	1.26	2.19	0.85	0.97	/	/
26	7.54	11.10	12.11	15.11	16.93	/	/	0.55	0.68	0.86	1.28	0.92	/	/
27	7.24	11.81	13.51	16.09	16.96	/	/	0.69	0.98	6.24	2.14	1.80	/	/
28	7.29	11.17	13.18	15.02	16.07	18.22	20.83	0.60	0.51	1.72	2.37	0.66	0.61	0.59
29	7.21	11.77	15.23	21.91	/	/	/	0.72	0.93	1.81	1.07	/	/	/
30	7.35	10.85	11.80	15.60	18.91	/	/	0.65	0.54	0.77	0.64	0.81	/	/
31	7.32	12.05	15.32	20.02	/	/	/	0.75	1.11	1.96	0.66	/	/	/
32	7.16	11.61	15.17	17.25	20.34	/	/	0.74	0.78	1.16	1.66	1.35	/	/
33	7.26	11.83	15.36	16.00	18.54	22.42	/	0.68	0.89	1.63	2.28	1.19	0.83	/
34	7.21	11.76	15.56	/	/	/	/	0.69	0.81	1.34	/	/	/	/
35	7.35	11.15	12.26	15.02	17.07	19.34	22.50	0.66	0.52	1.08	0.80	1.25	0.87	0.56
36	7.31	11.91	12.43	15.34	17.43	19.47	20.88	0.62	0.98	1.06	1.28	0.82	0.72	0.72
37	7.19	11.84	15.45	20.02	/	/	/	0.68	1.09	1.55	1.34	/	/	/
38	7.13	11.79	15.54	16.45	20.57	/	/	0.71	0.94	1.87	1.72	1.39	/	/
39	7.39	11.52	15.01	15.63	16.38	/	/	0.66	0.88	1.57	1.87	2.69	/	/
40	7.31	11.67	15.62	19.17	22.50	/	/	0.70	0.91	1.28	0.89	0.74	/	/
41	7.23	11.94	15.11	15.94	20.28	/	/	0.68	0.89	1.64	1.66	0.71	/	/
42	7.36	10.91	11.56	15.25	17.13	19.46	21.62	0.64	0.49	0.68	3.16	0.75	0.69	0.83
43	7.24	11.75	15.42	/	/	/	/	0.68	0.96	2.48	/	/	/	/
44	7.32	11.82	12.65	15.62	16.31	/	/	0.68	1.00	4.77	1.30	2.25	/	/
45	7.27	11.91	15.39	18.65	21.13	/	/	0.63	1.20	1.27	0.89	0.73	/	/
46	7.20	11.58	15.69	17.70	19.35	21.99	/	0.60	0.82	2.06	0.94	0.54	0.45	/
47	7.24	12.00	15.73	19.00	/	/	/	0.64	1.03	1.81	0.81	/	/	/
48	7.29	12.11	15.31	18.63	19.89	/	/	0.65	1.05	1.91	1.75	1.32	/	/
49	7.44	12.05	15.07	18.43	/	/	/	0.52	0.98	1.40	1.33	/	/	/
50	7.26	11.86	14.59	16.59	17.40	19.80	21.99	0.69	0.98	1.21	1.06	0.93	0.53	0.58
51	7.22	11.76	14.94	19.93	/	/	/	0.69	1.05	1.25	1.17	/	/	/
52	7.30	11.41	15.39	18.27	19.59	21.59	/	0.59	0.65	1.55	0.70	0.71	0.68	/
53	7.38	11.86	15.22	18.54	20.48	/	/	0.64	0.83	0.83	0.69	0.62	/	/
54	7.23	11.79	15.65	17.23	20.98	/	/	0.62	0.86	2.25	1.37	0.94	/	/
55	7.37	11.60	15.79	16.74	18.90	/	/	0.59	0.77	2.81	1.87	2.10	/	/
56	7.41	11.54	15.51	17.56	/	/	/	0.59	0.75	1.22	1.77	/	/	/
57	7.31	12.02	15.24	18.12	/	/	/	0.63	1.04	1.12	0.88	/	/	/
58	7.32	12.10	15.28	17.00	19.00	20.78	22.31	0.67	1.03	2.35	1.27	0.54	0.43	0.39
59	7.32	11.97	15.38	16.97	18.62	/	/	0.68	0.90	1.19	1.16	1.15	1.13	/
60	7.26	11.65	15.26	16.88	21.53	/	/	0.66	0.76	2.75	1.77	1.06	/	/
61	7.19	11.75	15.16	/	/	/	/	0.57	0.84	1.07	/	/	/	/
62	7.25	11.30	11.85	15.08	16.59	18.18	21.05	22.67	0.65	0.84	1.56	0.75	0.90	0.54
63	7.42	11.78	15.07	17.22	18.87	20.71	/	0.69	0.89	0.67	0.98	0.56	0.47	/
64	7.16	11.76	15.30	15.87	20.55	/	/	0.55	0.97	1.18	0.90	0.52	/	/
65	7.14	13.69	15.53	16.34	17.79	20.01	/	0.58	1.73	3.58	1.27	0.80	0.85	/
66	7.31	11.59	12.29	15.67	17.66	18.60	20.43	0.59	0.56	1.31	0.94	1.45	0.75	0.69
67	7.27	11.70	14.44	17.07	17.84	/	/	0.72	0.81	0.77	0.80	1.46	/	/
68	7.14	11.75	15.36	18.74	19.47	/	/	0.55	0.69	1.01	0.95	1.21	/	/
69	7.32	11.93	15.34	18.44	22.21	/	/	0.62	0.84	2.62	0.63	0.42	/	/
70	7.45	12.10	12.44	14.29	16.35	17.31	18.65	0.61	0.80	0.82	0.66	0.63	1.63	0.53
71	7.35	11.43	15.40	16.39	18.02	19.71	21.39	0.62	0.66	2.73	0.81	0.66	0.49	0.35
72	7.31	12.01	15.08	/	/	/	/	0.68	0.92	1.27	/	/	/	/
73	7.26	11.63	16.55	/	/	/	/	0.66	0.66	2.01	/	/	/	/
74	7.22	11.88	14.83	17.25	/	/	/	0.70	0.99	1.41	1.49	/	/	/
75	7.20	11.63	15.18	18.12	18.70	/	/	0.54	0.64	1.33	1.49	1.79	/	/
76	7.34	11.70	14.93	17.74	19.98	21.32	/	0.60	0.71	0.83	0.80	0.37	0.86	/
77	7.30	11.76	12.02	14.95	15.57	19.60	/	0.69	0.87	1.04	1.30	1.10	1.11	/
78	7.33	11.98	15.26	/	/	/	/	0.60	1.05	1.77	/	/	/	/
79	7.37	11.66	14.85	16.99	18.17	21.17	/	0.56	0.84	1.15	0.89	1.60	0.96	/
80	7.38	11.55	15.19	20.46	/	/	/	0.62	0.79	1.80	1.03	/	/	/
81	7.36	11.78	13.71	17.88	18.47	/	/	0.72	0.90	2.53	1.22	1.49	/	/
82	7.35	11.92	14.71	17.41	19.20	21.03	/	0.62	0.92	1.33	0.98	0.65	0.72	/
83	7.29	11.26	11.80	15.64	17.04	20.48	/	0.66	0.55	1.52	1.71	1.54	0.65	/
84	7.24	12.29	14.76	16.85	19.25	22.40	/	0.69	1.15	0.93	0.99	0.91	0.44	/
85	7.30	11.38	11.90	15.20	19.37	/	/	0.68	0.75	0.92	1.51	1.05	/	/
86	7.21	11.70	15.08	19.56	20.35	/	/	0.66	0.88	2.02	1.39	1.07	/	/
87	7.04	11.53	15.18	15.92	18.96	21.13	/	0.48	0.92	1.28	0.86	0.85	0.51	/
88	7.36	11.58	14.77	17.75	19.28	/	/	0.60	0.77	1.85	1.67	1.10	/	/
89	7.47	11.02	12.11	12.78	15.01	16.43	17.66	0.64	0.45	0.96	0.74	0.87	0.79	0.60
90	7.22	11.76	15.28	17.76	18.60	/	/	0.67	0.89	2.47	1.81	1.42	/	/
91	7.22	11.53	12.62	14.84	16.68	18.39	21.50	0.50	0.52	0.55	0.98	0.55	0.77	0.51
92	7.21	11.99	18.90	20.81	/	/	/	0.66	1.13	1.14	1.23	/	/	/
93	7.16	11.82	15.19	13.62	17.73	/	/	0.63	0.86	1.55	2.70	1.63	/	/
94	7.43	11.11	11.93	19.60	21.24	/	/	0.71	0.56	0.82	0.61	0.54	/	/
95	7.30	11.65	14.65	17.52	19.90	/	/	0.61	0.91	0.92	0.83	0.82	/	/
96	7.35	11.67	15.12	16.48	19.40	/	/	0.63	0.69	0.80	1.38	0.76	/	/
97	7.39	11.10	11.93	14.85	17.87	19.01	21.75	0.67	0.62	1.00	0.54	0.62	1.21	0.36
98	6.97	7.43	11.19	12.20	16.05	17.64	18.02	0.63	0.41	0.90	0.82	0.60	0.68	0.48
99	7.33	11.59	13.23	15.82	19.03	22.42	/	0.61	0.78	0.93	1.48	0.54	0.64	/
100	7.41	11.98	15.34	17.16	19.86	/	/	0.58	0.94	1.99	1.05	1.21	/	/

Appendix Table B.6b Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 1000 length measurements using the two partitions for grouping the Red mullet data.

	Sample size = 1000 length measurements													
	Estimates													
	1 cm													
	mean 1 (cm)	*mean 2 (cm)*	*mean 3 (cm)*	*mean 4 (cm)*	*mean 5 (cm)*	*mean 6 (cm)*	*mean 7 (cm)*	*SD 1 (cm)*	*SD 2 (cm)*	*SD 3 (cm)*	*SD 4 (cm)*	*SD 5 (cm)*	*SD 6 (cm)*	*SD 7 (cm)*
1	6.52	7.48	7.82	8.51	10.80	11.29	11.68	0.13	0.39	0.40	0.20	0.11	0.20	0.20
2	7.29	7.85	8.31	10.76	11.31	12.27	12.68	0.43	0.26	0.24	0.12	0.22	0.21	0.21
3	6.49	7.33	8.28	10.56	11.12	11.73	12.43	0.14	0.27	0.23	0.12	0.13	0.19	0.25
4	6.69	7.66	10.42	11.72	12.10	12.49	12.88	0.13	0.31	0.10	0.21	0.17	0.16	0.18
5	6.31	6.98	7.82	8.37	10.17	11.15	11.65	0.24	0.14	0.32	0.14	0.13	0.23	0.18
6	6.28	7.18	7.96	8.55	10.52	11.17	12.25	0.22	0.24	0.21	0.13	0.10	0.11	0.42
7	6.42	8.37	8.77	10.50	11.32	11.99	13.11	0.16	0.78	0.15	0.12	0.19	0.14	0.13
8	6.57	7.96	10.46	10.73	11.61	12.32	12.89	0.22	0.35	0.12	0.08	0.16	0.20	0.13
9	7.01	7.60	8.28	11.10	12.06	12.41	12.83	0.27	0.42	0.09	0.22	0.14	0.19	0.12
10	6.71	7.17	7.48	8.11	10.47	11.03	11.31	0.16	0.27	0.33	0.19	0.09	0.21	0.32
11	6.15	6.51	7.69	8.59	11.32	11.70	12.29	0.16	0.11	0.43	0.24	0.17	0.18	0.33
12	7.19	7.73	8.39	9.20	10.35	11.43	12.46	0.27	0.30	0.12	0.08	0.09	0.25	0.28
13	6.19	7.27	7.65	8.49	10.58	11.20	12.70	0.10	0.59	0.29	0.13	0.16	0.23	0.15
14	6.26	6.79	8.44	11.00	11.42	11.89	12.64	0.08	0.13	0.15	0.11	0.11	0.17	0.29
15	6.31	6.57	7.48	8.41	8.91	9.95	10.65	0.13	0.13	0.35	0.17	0.06	0.11	0.08
16	6.47	7.31	7.62	8.05	10.52	11.65	11.95	0.12	0.50	0.13	0.26	0.07	0.24	0.18
17	7.24	7.79	8.38	9.39	10.59	10.92	11.95	0.41	0.17	0.16	0.19	0.29	0.11	0.42
18	6.82	7.24	7.94	10.52	11.30	12.43	13.06	0.14	0.18	0.35	0.10	0.21	0.12	0.15
19	6.83	7.41	7.77	10.32	10.77	11.16	11.98	0.39	0.25	0.42	0.09	0.13	0.13	0.14
20	6.82	7.27	8.14	9.00	10.32	10.77	11.87	0.31	0.59	0.16	0.07	0.12	0.10	0.25
21	6.38	7.71	8.33	9.12	11.23	11.53	11.95	0.10	0.31	0.24	0.15	0.10	0.12	0.18
22	6.29	6.77	7.81	8.21	8.88	10.25	10.89	0.14	0.13	0.13	0.12	0.14	0.09	0.13
23	6.42	7.44	8.00	8.78	10.12	11.36	11.90	0.11	0.19	0.36	0.17	0.10	0.13	0.25
24	6.44	6.86	7.55	8.21	9.40	10.75	11.05	0.17	0.16	0.44	0.28	0.08	0.13	0.11
25	6.72	7.09	7.62	8.35	9.20	11.04	12.74	0.17	0.14	0.15	0.12	0.08	0.10	0.99
26	6.52	7.37	8.21	10.57	10.85	11.24	11.57	0.19	0.37	0.14	0.21	0.14	0.11	0.10
27	6.51	7.43	8.79	10.39	10.83	11.38	11.63	0.30	0.15	0.16	0.13	0.13	0.11	0.38
28	6.72	7.25	7.95	10.45	10.83	11.34	11.63	0.15	0.35	0.27	0.08	0.12	0.15	0.31
29	6.29	7.17	7.94	8.47	10.88	11.30	11.77	0.13	0.13	0.44	0.21	0.15	0.19	0.29
30	6.10	6.55	7.35	8.22	8.68	10.52	10.83	0.08	0.13	0.19	0.34	0.10	0.11	0.09
31	6.81	7.47	8.56	10.20	10.58	10.94	11.64	0.23	0.69	0.23	0.12	0.12	0.19	0.12
32	6.49	7.43	8.15	8.61	10.58	11.64	12.77	0.16	0.28	0.22	0.16	0.17	0.26	0.24
33	6.40	7.03	7.96	8.52	9.20	10.54	11.37	0.13	0.17	0.18	0.19	0.08	0.12	0.14
34	6.21	7.29	7.92	8.78	11.05	11.37	11.87	0.11	0.17	0.17	0.16	0.13	0.13	0.15
35	6.40	7.13	7.92	9.10	10.55	10.96	11.99	0.15	0.20	0.15	0.07	0.13	0.17	0.15
36	6.11	7.01	8.63	10.82	11.60	13.30	13.72	0.06	0.19	0.20	0.11	0.22	0.11	0.10
37	6.15	6.72	7.36	8.30	11.18	11.58	12.55	0.14	0.12	0.15	0.39	0.14	0.23	0.12
38	6.38	6.72	7.52	8.07	8.92	10.45	10.98	0.10	0.12	0.25	0.20	0.13	0.09	0.18
39	6.28	6.95	7.80	8.53	9.25	10.48	10.92	0.17	0.32	0.31	0.19	0.09	0.14	0.11
40	6.57	7.65	8.90	10.51	10.89	11.26	12.55	0.12	0.22	0.12	0.14	0.15	0.08	0.19
41	6.72	7.50	8.08	10.30	11.41	11.95	12.50	0.32	0.23	0.32	0.19	0.19	0.18	0.13
42	6.55	7.13	7.67	8.15	8.71	10.30	10.61	0.12	0.26	0.43	0.30	0.12	0.12	0.13
43	6.35	7.35	8.40	10.50	11.20	11.82	12.20	0.13	0.53	0.21	0.12	0.25	0.15	0.56
44	6.57	7.02	7.63	8.46	9.65	10.00	10.53	0.24	0.39	0.55	0.13	0.17	0.07	0.11
45	6.58	7.37	7.95	9.25	10.90	11.99	12.43	0.15	0.67	0.30	0.10	0.15	0.15	0.21
46	6.43	7.31	8.28	10.34	11.07	11.56	12.55	0.13	0.26	0.13	0.16	0.17	0.24	0.16
47	6.68	7.51	8.52	10.55	11.08	11.53	12.46	0.19	0.71	0.13	0.12	0.13	0.29	0.13
48	6.15	6.58	7.30	7.98	8.63	10.95	11.89	0.10	0.12	0.18	0.27	0.15	0.13	0.22
49	6.38	6.90	7.49	8.20	10.35	11.35	12.07	0.09	0.26	0.36	0.14	0.14	0.15	0.22
50	6.45	7.31	7.82	9.85	10.44	10.82	11.38	0.25	0.23	0.14	0.11	0.13	0.11	0.23
51	6.00	7.12	7.75	10.56	10.89	11.25	11.55	0.07	0.45	0.45	0.18	0.24	0.16	0.15
52	6.55	7.34	8.34	10.45	10.93	11.43	12.42	0.12	0.38	0.15	0.11	0.14	0.11	0.11
53	6.47	7.26	8.03	11.09	11.52	11.90	12.23	0.16	0.22	0.18	0.12	0.19	0.16	0.19
54	6.19	7.35	8.24	10.25	10.86	11.74	12.38	0.10	0.54	0.22	0.10	0.24	0.13	0.32
55	6.68	7.43	8.04	8.62	10.32	10.75	12.09	0.16	0.25	0.16	0.08	0.09	0.14	0.24
56	6.25	7.89	8.52	10.47	10.97	11.37	12.56	0.11	1.26	0.08	0.13	0.11	0.17	0.13
57	6.87	7.60	8.73	10.28	11.06	11.35	12.29	0.32	0.43	0.16	0.11	0.10	0.13	0.12
58	6.53	6.95	7.84	8.19	10.53	11.62	12.38	0.23	0.18	0.23	0.11	0.11	0.20	0.28
59	5.92	7.75	8.34	10.65	11.04	11.81	12.32	0.08	0.80	0.16	0.11	0.12	0.22	0.18
60	6.59	6.95	7.98	8.70	10.69	11.16	11.51	0.15	0.22	0.15	0.10	0.17	0.13	0.14
61	6.77	7.48	8.26	9.00	10.93	11.63	12.39	0.19	0.36	0.12	0.12	0.14	0.20	0.12
62	6.85	7.64	8.83	11.13	11.82	12.36	13.34	0.17	0.26	0.15	0.23	0.16	0.40	0.19
63	6.30	7.32	7.88	8.55	10.05	10.51	11.46	0.10	0.26	0.46	0.20	0.17	0.12	0.12
64	6.32	7.07	7.54	8.28	10.73	11.38	11.90	0.10	0.27	0.16	0.25	0.08	0.12	0.14
65	6.52	7.47	7.96	10.62	11.16	11.78	12.52	0.17	0.29	0.21	0.12	0.16	0.17	0.13
66	6.34	6.83	7.40	8.31	9.02	11.27	12.05	0.08	0.23	0.28	0.12	0.15	0.21	0.19
67	6.22	7.35	8.00	8.61	11.10	11.42	11.73	0.16	0.60	0.29	0.10	0.13	0.21	0.20
68	6.70	7.34	8.02	8.85	10.55	11.41	11.82	0.13	0.18	0.30	0.13	0.10	0.14	0.17
69	6.33	7.34	8.33	10.50	10.97	11.52	12.46	0.10	0.24	0.22	0.12	0.11	0.17	0.27
70	6.99	7.45	8.44	11.54	11.83	12.61	14.08	0.22	0.61	0.18	0.16	0.16	0.14	0.14
71	6.31	7.36	7.90	8.49	11.11	11.52	11.99	0.10	0.39	0.30	0.20	0.14	0.12	0.15
72	6.31	7.09	7.65	8.70	9.40	11.35	11.84	0.14	0.20	0.23	0.10	0.07	0.17	0.13
73	6.68	7.03	7.78	8.50	10.42	11.17	12.14	0.22	0.16	0.38	0.14	0.91	0.28	0.16
74	6.27	7.56	8.33	9.07	10.55	11.02	11.60	0.09	0.30	0.17	0.13	0.16	0.09	0.10
75	6.36	6.73	8.49	10.91	12.00	12.68	13.08	0.14	0.12	0.15	0.13	0.24	0.19	0.16
76	6.70	7.59	8.57	10.15	10.78	11.42	13.01	0.15	0.26	0.14	0.12	0.11	0.69	0.19
77	6.26	7.21	7.91	8.24	10.71	11.72	12.34	0.12	0.33	0.16	0.20	0.13	0.19	0.18
78	6.27	6.81	7.95	10.93	12.31	12.95	13.90	0.14	0.20	0.35	0.13	0.23	0.29	0.15
79	6.41	7.43	8.29	10.57	11.17	11.60	12.93	0.10	0.61	0.19	0.15	0.21	0.43	0.18
80	6.50	7.77	8.49	9.01	10.49	11.10	11.98	0.18	0.44	0.18	0.13	0.17	0.18	0.14
81	6.33	7.29	8.01	9.20	10.92	11.22	12.28	0.14	0.12	0.21	0.06	0.18	0.31	0.12
82	6.05	7.10	7.52	8.25	9.30	10.41	10.95	0.10	0.46	0.45	0.23	0.19	0.12	0.16
83	6.12	7.19	7.63	8.46	10.51	11.08	11.72	0.11	0.41	0.23	0.15	0.11	0.14	0.12
84	6.22	7.01	8.21	10.63	11.44	12.23	12.62	0.07	0.26	0.21	0.09	0.17	0.15	0.14
85	6.39	7.00	7.63	8.38	10.35	11.66	12.40	0.17	0.24	0.15	0.15	0.09	0.17	0.10
86	6.56	7.15	7.68	8.47	10.42	10.92	11.72	0.12	0.16	0.32	0.14	0.14	0.11	0.23
87	6.43	6.88	7.43	8.57	8.90	10.40	11.04	0.23	0.18	0.20	0.15	0.10	0.13	0.13
88	6.49	7.39	8.23	10.71	11.13	11.81	12.51	0.13	0.64	0.23	0.17	0.12	0.16	0.22
89	6.39	6.94	7.70	8.55	10.35	10.79	11.29	0.10	0.24	0.30	0.21	0.12	0.17	0.19
90	6.52	7.02	7.65	10.53	10.90	11.41	12.43	0.26	0.30	0.28	0.09	0.10	0.15	0.15
91	6.64	7.27	7.90	9.12	11.29	12.25	12.89	0.20	0.16	0.37	0.14	0.41	0.17	0.17
92	7.29	7.92	8.44	9.23	10.59	10.98	11.43	0.25	0.25	0.10	0.08	0.13	0.12	0.10
93	6.26	6.76	7.60	8.18	9.02	10.49	10.96	0.10	0.15	0.35	0.29	0.08	0.11	0.13
94	6.44	6.83	8.32	9.05	10.38	10.81	11.72	0.11	0.14	0.24	0.09	0.11	0.13	0.26
95	6.40	7.52	8.52	10.75	12.10	12.83	13.71	0.12	0.44	0.18	0.14	0.29	0.18	0.15
96	6.44	7.51	8.46	8.81	10.55	12.41	13.83	0.15	0.42	0.15	0.11	0.12	0.30	0.23
97	6.57	7.02	7.83	8.46	10.40	10.75	11.85	0.19	0.09	0.15	0.15	0.13	0.14	0.26
98	6.03	6.43	7.16	7.67	11.08	12.17	12.91	0.10	0.12	0.15	0.54	0.19	0.71	0.17
99	6.48	7.68	8.53	10.65	10.96	11.22	12.00	0.21	0.29	0.10	0.13	0.10	0.08	0.17
100	6.05	7.09	8.21	8.47	10.75	11.38	12.64	0.11	0.31	0.16	0.17	0.12	0.22	0.42

Appendix Table B.6c Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 1000 length measurements using the two partitions for grouping the Red mullet data.

Sample size = 1000 length measurements														
% Bias														
Birgè and Rozenholc algorithm														
	mean 1	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*mean 7*	*SD 1*	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*	*SD 7*
1	-5.63	6.19	1.71	3.71	/	/	/	-4.28	38.45	33.38	-30.46	/	/	/
2	-5.47	-2.55	-0.28	-7.91	-0.38	/	/	0.25	-1.04	46.01	76.61	9.29	/	/
3	-2.83	-6.60	4.89	5.38	7.53	/	/	-0.01	-22.68	-25.08	4.46	-33.39	/	/
4	-5.33	-3.73	3.03	11.92	21.72	/	/	-15.58	-16.06	34.06	-62.33	-67.77	/	/
5	-4.24	0.37	-5.72	-1.65	-5.11	2.40	/	5.22	12.14	85.29	29.12	3.50	-41.68	/
6	-4.69	-6.36	-5.42	0.28	5.84	/	/	-0.32	-24.19	157.96	-25.88	15.00	/	/
7	-3.54	-1.77	1.31	9.08	7.13	5.05	/	-6.08	-0.15	80.07	-38.62	-4.27	-37.85	/
8	-5.28	-3.65	1.76	-2.92	/	/	/	-8.05	18.92	41.32	75.91	/	/	/
9	-6.17	-2.78	3.53	-0.88	/	/	/	17.20	4.90	118.06	-26.24	/	/	/
10	-4.14	-8.34	-19.87	-10.50	-8.90	-3.75	-0.32	-4.66	-28.15	0.47	29.55	-37.75	-67.31	-71.86
11	-3.29	-5.21	-2.53	-0.76	18.56	/	/	-3.48	-42.24	-27.90	-41.60	-68.31	/	/
12	-4.27	-4.15	-0.36	-6.87	-0.44	0.30	/	-1.66	-7.09	1.44	-39.76	-56.19	-41.34	/
13	-5.60	-0.65	0.36	-3.27	/	/	/	7.68	25.08	111.51	76.01	/	/	/
14	-4.27	-3.37	-0.72	-6.14	10.41	17.27	/	-2.65	-0.49	23.43	32.76	-57.85	-55.87	/
15	-4.10	-8.56	-21.88	-1.04	-2.44	/	/	6.96	-26.76	19.19	-6.39	-22.93	/	/
16	-4.85	-0.84	-2.44	-3.21	7.13	/	/	5.28	4.26	92.89	-27.14	-36.15	/	/
17	-5.33	-0.11	-1.39	2.91	/	/	/	1.26	16.45	-4.47	-21.67	/	/	/
18	-1.01	-4.25	-12.97	-12.67	-11.04	-12.94	-9.04	-9.48	-21.31	-45.73	-18.89	-38.37	-61.38	-70.97
19	-4.15	-4.51	1.75	/	/	/	/	-4.59	1.49	140.26	/	/	/	/
20	-5.12	-9.22	-18.28	-10.70	-3.38	-7.42	/	-5.73	-40.24	37.47	-30.89	-29.92	-47.96	/
21	-3.46	-0.26	3.60	-0.47	15.66	/	/	5.96	-7.46	-15.48	19.18	-44.43	/	/
22	-3.53	-3.71	0.68	-0.73	/	/	/	1.58	-7.59	-30.92	-42.50	/	/	/
23	-3.37	-7.61	-21.29	-10.14	6.80	/	/	4.47	-22.44	-14.86	-25.25	-40.62	/	/
24	-3.04	-2.23	-11.85	-10.99	5.24	4.73	/	-2.48	-22.88	-6.69	-46.52	-36.79	-64.60	/
25	-3.26	1.19	2.65	1.98	16.78	/	/	4.41	39.58	90.62	-39.44	-41.17	/	/
26	-0.80	-8.42	-19.98	-12.10	-7.80	/	/	-15.82	-23.95	-25.05	-8.23	-44.39	/	/
27	-4.70	-2.54	-10.74	-6.44	-7.65	/	/	5.28	8.35	442.33	52.62	9.00	/	/
28	-4.08	-7.85	-12.95	-12.66	-12.50	-6.88	-0.27	-7.48	-43.28	49.60	69.61	-59.81	-67.83	-72.45
29	-5.09	-2.87	0.61	27.41	/	/	/	10.33	3.26	57.05	-23.67	/	/	/
30	-3.26	-10.46	-22.04	-9.28	2.96	/	/	-0.60	-40.51	-32.96	-54.12	-51.16	/	/
31	-3.65	-0.59	1.23	16.43	/	/	/	15.73	23.75	70.40	-53.21	/	/	/
32	-5.75	-4.21	0.23	0.31	10.73	/	/	14.15	-13.16	0.74	18.23	-18.29	/	/
33	-4.51	-2.39	1.50	-6.94	0.93	14.62	/	5.00	-1.62	41.40	62.60	-27.70	-56.23	/
34	-5.12	-2.96	2.83	/	/	/	/	6.41	-10.61	16.91	/	/	/	/
35	-3.31	-8.00	-19.01	-12.64	-7.03	-1.16	7.75	0.89	-42.40	-6.50	-42.76	-24.22	-54.06	-74.07
36	-3.87	-1.71	-17.87	-10.77	-5.10	-0.49	-0.01	-4.10	9.25	-7.54	-8.29	-50.60	-62.10	-66.61
37	-5.42	-2.31	2.05	16.44	/	/	/	4.19	20.89	34.59	-4.11	/	/	/
38	-6.21	-2.75	2.67	-4.35	11.98	/	/	9.47	4.12	62.82	22.66	-15.97	/	/
39	-2.74	-4.92	-0.82	-9.07	-10.83	/	/	1.32	-2.68	36.61	33.63	62.74	/	/
40	-3.86	-3.74	3.23	11.49	22.53	/	/	7.61	0.62	11.50	-36.21	-55.28	/	/
41	-4.86	-1.46	-0.20	-7.28	10.43	/	/	4.21	-1.10	42.46	18.86	-56.78	/	/
42	-3.18	-9.96	-23.65	-11.27	-6.71	-0.53	3.54	-0.93	-45.53	-40.89	125.69	-54.66	-63.77	-61.46
43	-4.77	-3.07	1.85	/	/	/	/	4.20	6.93	115.46	/	/	/	/
44	-3.68	-2.51	-16.43	-9.15	-11.21	/	/	4.82	11.07	314.49	-7.21	36.18	/	/
45	-4.37	-1.71	1.68	8.47	15.06	/	/	-3.85	33.52	10.38	-36.63	-55.69	/	/
46	-5.31	-4.49	3.68	2.94	5.38	12.40	/	-7.82	-9.30	78.85	-33.19	-67.04	-76.26	/
47	-4.71	-0.96	3.95	10.52	/	/	/	-1.66	14.71	57.22	-42.42	/	/	/
48	-4.12	-0.05	1.16	8.36	8.33	/	/	0.61	16.14	66.34	25.17	-20.07	/	/
49	-2.12	-0.60	-0.40	7.17	/	/	/	-20.47	8.71	22.00	-4.72	/	/	/
50	-4.52	-2.18	-3.59	-3.50	-5.23	1.22	5.31	6.30	8.66	5.32	-24.65	-43.51	-71.91	-72.79
51	-5.04	-2.96	-1.29	15.92	/	/	/	5.37	16.26	8.63	-16.37	/	/	/
52	-3.98	-5.86	1.69	6.25	6.69	10.33	/	-8.91	-27.79	34.46	-49.96	-56.96	-64.06	/
53	-2.87	-2.14	0.55	7.84	11.54	/	/	-1.80	-7.85	-27.73	-50.51	-62.38	/	/
54	-4.84	-2.74	3.39	0.23	14.26	/	/	-5.21	-3.98	95.80	-2.04	-42.73	/	/
55	-3.08	-4.32	4.30	-2.63	2.92	/	/	-9.58	-14.29	143.91	33.77	27.07	/	/
56	-2.51	-4.79	2.48	2.12	/	/	/	-9.15	-17.14	6.24	26.64	/	/	/
57	-3.85	-0.84	0.69	5.40	/	/	/	-2.87	15.24	-2.56	-37.13	/	/	/
58	-3.63	-0.17	0.94	-1.12	3.47	6.19	6.81	3.29	14.63	103.87	-9.29	-67.14	-77.15	-81.63
59	-3.63	-1.25	1.61	-1.29	1.38	/	/	3.78	0.08	3.12	-16.83	-30.34	-40.51	/
60	-4.42	-3.86	0.79	-1.82	17.25	/	/	1.79	-15.45	139.22	26.68	-35.54	/	/
61	-5.36	-3.10	0.19	/	/	/	/	-11.79	-7.15	-6.81	/	/	/	/
62	-4.60	-6.74	-21.72	-12.31	-9.65	-7.09	0.80	3384.40	-28.19	-27.26	11.33	-54.68	-52.60	-74.90
63	-2.39	-2.84	-0.43	0.17	2.75	5.85	/	5.38	-1.00	-41.37	-29.74	-66.27	-75.05	/
64	-5.73	-2.95	1.07	-7.67	11.92	/	/	-15.32	7.23	2.74	-35.49	-68.79	/	/
65	-6.11	12.98	2.60	-4.95	-3.12	2.29	/	-10.11	91.86	211.47	-9.08	-51.78	-55.25	/
66	-3.85	-4.37	-18.77	-8.85	-3.87	-4.96	-2.19	-9.04	-38.20	13.86	-32.80	-12.05	-60.37	-67.78
67	-4.32	-3.48	-4.61	-0.71	-2.85	/	/	10.38	-10.50	-32.94	-42.65	-11.58	/	/
68	-6.04	-3.05	1.49	8.97	6.00	/	/	-14.72	-23.36	-11.88	-32.29	-26.84	/	/
69	-3.70	-1.57	1.36	7.24	20.93	/	/	-4.08	-6.61	127.89	-55.25	-74.77	/	/
70	-1.98	-0.18	-17.82	-16.86	-10.98	-11.51	-10.68	-6.64	-10.81	-29.02	-52.82	-61.58	-14.02	-75.33
71	-3.32	-5.73	1.77	-4.69	-1.88	0.72	2.40	-4.94	-26.80	137.48	-42.49	-60.05	-74.33	-83.94
72	-3.82	-0.91	-0.39	/	/	/	/	4.42	1.69	10.08	/	/	/	/
73	-4.41	-4.06	9.33	/	/	/	/	0.72	-27.25	74.71	/	/	/	/
74	-4.99	-2.02	-2.04	0.34	/	/	/	7.71	10.15	22.93	6.56	/	/	/
75	-5.31	-4.04	0.33	5.42	1.82	/	/	-17.04	-29.45	15.48	6.41	8.71	/	/
76	-3.43	-3.48	-1.38	3.19	8.79	8.97	/	-7.74	-20.68	-27.88	-42.58	-77.69	-54.67	/
77	-4.01	-2.94	-20.60	-13.04	-15.21	0.20	/	5.56	-2.88	-9.74	-7.12	-33.29	-41.69	/
78	-3.56	-1.18	0.81	/	/	/	/	-7.89	16.35	54.29	/	/	/	/
79	-3.08	-3.84	-1.85	-1.20	-1.06	8.23	/	-14.14	-6.72	0.23	-36.65	-2.90	-49.23	/
80	-2.85	-4.68	0.37	18.99	/	/	/	-4.29	-12.20	56.58	-26.33	/	/	/
81	-3.15	-2.85	-9.42	3.97	0.54	/	/	10.66	-0.15	119.69	-13.18	-9.97	/	/
82	-3.34	-1.69	-2.78	1.24	4.57	7.48	/	-4.63	1.99	15.79	-30.28	-60.31	-61.96	/
83	-4.12	-7.08	-22.02	-9.01	-7.20	4.68	/	0.75	-38.65	32.21	22.32	-6.48	-65.77	/
84	-4.67	1.42	-2.48	-1.99	4.84	14.48	/	5.85	27.92	-18.85	-29.44	-44.95	-76.85	/
85	-3.93	-6.12	-21.36	-11.58	5.45	/	/	4.66	-16.35	-19.85	7.91	-36.25	/	/
86	-5.13	-3.51	-0.35	13.79	10.79	/	/	1.67	-2.76	75.60	-0.48	-34.94	/	/
87	-7.37	-4.90	0.30	-7.41	3.24	7.98	/	-26.08	2.07	10.92	-38.45	-48.55	-73.18	/
88	-3.17	-4.49	-2.40	3.25	4.96	/	/	-8.05	-14.90	60.75	19.16	-33.37	/	/
89	-1.70	-9.05	-19.97	-25.70	-18.28	-16.01	-15.42	-2.36	-50.35	-16.45	-47.48	-47.01	-58.60	-72.19
90	-4.95	-2.97	0.92	3.31	1.26	/	/	3.05	-1.65	114.34	29.61	-14.21	/	/
91	-5.01	-4.87	-16.65	-13.69	-9.20	-6.00	2.94	-22.52	-42.77	-52.23	-30.18	-66.83	-59.50	-76.09
92	-5.13	-1.10	24.86	21.03	/	/	/	0.96	25.08	-0.82	-11.93	/	/	/
93	-5.75	-2.48	0.37	-20.80	-3.43	/	/	-3.57	-4.46	34.72	92.90	-1.15	/	/
94	-2.26	-8.37	-21.16	14.01	15.65	/	/	8.56	-37.55	-29.06	-56.14	-67.39	/	/
95	-3.92	-3.86	-3.19	1.93	8.38	/	/	-6.21	1.02	-19.68	-40.43	-50.12	/	/
96	-3.23	-3.75	-0.13	-4.16	5.61	/	/	-3.37	-23.48	-30.85	-1.40	-53.68	/	/
97	-2.82	-8.45	-21.17	-13.64	-2.68	-2.83	4.16	3.55	-31.63	-13.43	-61.39	-62.55	-36.08	-83.49
98	-8.33	-38.73	-26.09	-29.04	-12.59	-9.86	-13.73	-2.47	-54.28	-21.60	-41.55	-63.35	-64.46	-77.48
99	-3.59	-4.35	-12.62	-7.98	3.59	14.61	/	-5.76	-12.91	-18.85	5.54	-67.44	-66.15	/
100	-2.45	-1.20	1.36	-0.17	8.13	/	/	-10.18	4.69	72.68	-25.19	-26.64	/	/

Appendix Table B.6d Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 1000 length measurements using the two partitions for grouping the Red mullet data.

	Sample size = 1000 length measurements													
	% Bias													
	1 cm													
	mean 1	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*mean 7*	*SD 1*	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*	*SD 7*
1	-14.18	-38.30	-48.32	-50.52	-41.21	-42.31	-44.06	-79.37	-56.86	-64.99	-85.46	-93.09	-89.37	-90.87
2	-4.08	-35.21	-45.13	-37.39	-38.40	-37.29	-39.29	-33.51	-71.60	-79.51	-91.42	-86.87	-89.15	-90.40
3	-14.60	-39.49	-45.29	-38.56	-39.47	-40.03	-40.47	-78.90	-69.62	-79.92	-91.42	-91.94	-90.22	-88.50
4	-11.94	-36.77	-31.15	-31.84	-34.11	-36.14	-38.31	-80.28	-66.04	-91.22	-84.74	-89.71	-91.48	-91.58
5	-16.93	-42.44	-48.35	-51.33	-44.61	-42.99	-44.22	-62.84	-84.45	-72.15	-90.18	-92.16	-87.67	-91.40
6	-17.40	-40.80	-47.40	-50.27	-42.71	-42.91	-41.33	-65.87	-72.95	-82.04	-91.07	-93.88	-94.25	-80.28
7	-15.51	-30.99	-42.03	-38.91	-38.35	-38.70	-37.21	-75.87	-13.31	-86.72	-91.42	-88.61	-92.81	-94.12
8	-13.55	-34.33	-30.92	-37.56	-36.78	-37.02	-38.26	-66.55	-61.63	-89.65	-94.16	-90.48	-89.35	-93.95
9	-7.72	-37.30	-45.30	-35.44	-34.31	-36.58	-38.55	-58.86	-53.59	-92.43	-84.00	-91.67	-90.09	-94.44
10	-11.71	-40.84	-50.59	-52.85	-43.00	-43.62	-45.84	-75.23	-69.73	-71.47	-86.46	-94.56	-88.72	-85.29
11	-19.08	-46.27	-49.21	-50.06	-38.34	-40.19	-41.16	-75.87	-88.04	-62.43	-82.59	-89.56	-90.65	-84.72
12	-5.34	-36.25	-44.54	-46.49	-43.64	-41.57	-40.33	-58.19	-67.05	-89.31	-93.93	-94.79	-86.62	-86.80
13	-18.57	-40.06	-49.45	-50.60	-42.39	-42.76	-39.20	-84.22	-34.22	-74.45	-90.65	-90.28	-87.98	-92.97
14	-17.60	-44.00	-44.23	-36.01	-37.81	-39.21	-39.45	-87.14	-85.69	-86.64	-92.26	-93.41	-90.82	-86.61
15	-16.96	-45.76	-50.56	-51.07	-51.47	-49.14	-49.01	-79.64	-85.02	-69.98	-88.05	-96.44	-94.44	-96.21
16	-14.81	-39.65	-49.62	-53.18	-42.74	-40.47	-42.78	-82.28	-44.93	-88.48	-81.18	-95.80	-87.21	-91.50
17	-4.72	-35.73	-44.65	-45.38	-42.31	-44.18	-42.78	-37.66	-81.57	-86.21	-86.68	-82.34	-94.22	-80.63
18	-10.30	-40.24	-47.56	-38.81	-38.49	-36.48	-37.46	-78.67	-79.67	-69.85	-92.79	-87.39	-93.79	-93.08
19	-10.07	-38.83	-48.66	-39.98	-41.33	-42.97	-42.64	-39.86	-71.95	-63.67	-93.44	-91.82	-93.11	-93.52
20	-10.24	-40.03	-46.20	-47.65	-43.81	-44.96	-43.18	-51.97	-33.96	-85.91	-95.18	-92.55	-94.70	-88.27
21	-16.05	-36.41	-44.96	-46.96	-38.88	-41.05	-42.80	-84.79	-65.59	-78.77	-89.49	-93.67	-93.73	-91.43
22	-17.22	-44.17	-48.42	-52.26	-51.67	-47.61	-47.85	-78.05	-85.09	-88.43	-91.47	-91.35	-95.28	-93.83
23	-15.49	-38.63	-47.14	-48.95	-44.89	-41.94	-43.00	-83.76	-78.60	-69.00	-88.05	-93.88	-92.90	-88.34
24	-15.27	-43.42	-50.12	-52.23	-48.82	-45.06	-47.09	-73.48	-82.42	-61.47	-79.66	-94.85	-92.90	-94.89
25	-11.56	-41.54	-49.63	-51.43	-49.91	-43.60	-38.98	-74.20	-84.26	-86.67	-91.57	-94.85	-94.60	-53.87
26	-14.19	-39.17	-45.76	-38.55	-40.92	-42.56	-44.61	-71.04	-58.82	-87.59	-84.84	-91.35	-94.39	-95.17
27	-14.34	-38.68	-41.90	-39.56	-41.02	-41.85	-44.29	-53.90	-83.17	-86.51	-90.36	-91.82	-94.28	-82.27
28	-11.52	-40.23	-47.45	-39.22	-41.03	-42.06	-44.31	-77.37	-60.93	-76.27	-94.52	-92.74	-92.33	-85.53
29	-17.28	-40.82	-47.51	-50.74	-40.76	-42.25	-43.64	-80.58	-85.02	-62.11	-84.90	-91.05	-89.80	-86.48
30	-19.74	-45.96	-51.46	-52.17	-52.72	-46.22	-48.14	-86.95	-85.41	-83.57	-75.52	-93.82	-94.20	-95.83
31	-10.39	-38.38	-43.42	-40.65	-42.37	-44.08	-44.25	-64.81	-23.78	-80.39	-91.76	-92.72	-90.14	-94.41
32	-14.66	-38.71	-46.14	-49.95	-42.38	-40.52	-38.83	-74.84	-69.03	-81.18	-88.27	-89.64	-86.15	-88.98
33	-15.76	-41.99	-47.43	-50.45	-49.91	-46.11	-45.56	-79.85	-81.25	-83.94	-86.65	-94.85	-93.60	-93.37
34	-18.26	-39.86	-47.65	-48.94	-39.83	-41.89	-43.16	-83.44	-81.09	-85.63	-88.78	-91.92	-93.04	-92.97
35	-15.85	-41.16	-47.66	-47.07	-42.55	-44.00	-42.57	-77.66	-77.99	-86.69	-95.18	-91.82	-91.06	-93.00
36	-19.58	-42.16	-43.01	-37.06	-36.84	-32.03	-34.32	-90.96	-78.61	-82.31	-91.85	-86.93	-94.13	-95.15
37	-19.02	-44.58	-51.34	-51.71	-39.15	-40.80	-39.91	-79.02	-87.15	-87.35	-71.94	-91.72	-87.73	-94.21
38	-16.01	-44.56	-50.32	-53.05	-51.43	-46.59	-47.44	-85.34	-86.98	-78.55	-85.59	-92.15	-95.42	-91.83
39	-17.40	-42.70	-48.48	-50.37	-49.63	-46.45	-47.72	-73.90	-64.37	-73.38	-86.70	-94.56	-92.69	-94.75
40	-13.55	-36.92	-41.17	-38.88	-40.69	-42.46	-39.90	-81.10	-75.85	-89.98	-90.25	-90.84	-95.54	-91.34
41	-11.62	-38.16	-46.58	-40.08	-37.87	-38.91	-40.15	-50.77	-74.08	-72.51	-86.37	-88.34	-90.29	-94.03
42	-13.82	-41.21	-49.31	-52.58	-52.56	-47.34	-49.19	-81.49	-71.09	-62.83	-78.68	-93.01	-93.58	-93.90
43	-16.45	-39.39	-44.49	-38.91	-39.02	-39.59	-41.56	-80.70	-40.98	-82.07	-91.42	-85.00	-92.04	-74.10
44	-13.57	-42.12	-49.62	-50.80	-47.45	-48.89	-49.57	-62.82	-57.02	-51.89	-90.50	-89.71	-96.45	-94.70
45	-13.36	-39.21	-47.46	-46.20	-40.65	-38.71	-40.48	-77.01	-26.14	-73.49	-93.19	-91.05	-91.85	-90.45
46	-15.39	-39.70	-45.28	-39.85	-39.74	-40.90	-39.91	-80.58	-71.34	-88.56	-88.35	-89.73	-87.17	-92.46
47	-12.11	-38.02	-43.73	-38.64	-39.67	-41.08	-40.35	-71.09	-21.40	-88.85	-91.21	-92.05	-84.86	-94.06
48	-19.08	-45.74	-51.80	-53.59	-53.02	-44.04	-43.08	-85.34	-86.95	-84.23	-80.58	-91.13	-93.22	-89.92
49	-16.01	-43.09	-50.54	-52.32	-43.62	-41.97	-42.20	-86.91	-70.92	-68.75	-90.20	-91.54	-92.13	-89.88
50	-15.11	-39.67	-48.31	-42.71	-43.17	-44.71	-45.52	-61.28	-74.16	-87.65	-92.45	-92.10	-94.39	-89.11
51	-21.05	-41.27	-48.79	-38.60	-40.72	-42.50	-44.70	-88.65	-49.84	-60.76	-86.91	-85.22	-91.46	-93.13
52	-13.75	-39.48	-44.87	-39.22	-40.49	-41.56	-40.53	-81.10	-58.21	-86.80	-92.45	-91.36	-94.22	-94.75
53	-14.88	-40.12	-46.94	-35.49	-37.29	-39.19	-41.45	-75.17	-75.97	-84.34	-91.42	-88.36	-91.81	-91.30
54	-18.62	-39.37	-45.53	-40.38	-40.88	-39.99	-40.74	-84.93	-40.28	-80.75	-93.19	-85.31	-93.00	-85.18
55	-12.04	-38.67	-46.91	-49.83	-43.82	-45.08	-42.12	-75.28	-72.17	-86.42	-94.10	-94.35	-92.76	-88.85
56	-17.76	-34.91	-43.68	-39.08	-40.28	-41.89	-39.86	-82.87	39.77	-92.64	-90.76	-93.24	-91.02	-93.94
57	-9.57	-37.28	-42.32	-40.23	-39.78	-41.99	-41.16	-50.37	-52.44	-85.73	-92.45	-93.86	-92.90	-94.39
58	-14.09	-42.66	-48.22	-52.36	-42.66	-40.59	-40.72	-64.42	-80.30	-80.35	-92.05	-93.26	-89.45	-87.11
59	-22.07	-36.05	-44.93	-38.06	-39.91	-39.61	-41.03	-87.47	-11.06	-86.29	-92.45	-92.72	-88.31	-91.39
60	-13.28	-42.66	-47.25	-49.37	-41.80	-42.96	-44.89	-77.26	-75.65	-87.03	-92.88	-89.71	-93.19	-93.42
61	-10.90	-38.25	-45.46	-47.67	-40.47	-40.55	-40.69	-71.53	-59.59	-89.71	-91.42	-91.35	-89.25	-94.19
62	-9.86	-36.98	-41.66	-35.26	-35.65	-36.83	-36.11	-73.70	-70.65	-86.55	-83.82	-90.10	-79.07	-91.05
63	-17.11	-39.62	-47.94	-50.25	-45.28	-46.27	-45.14	-85.26	-71.30	-59.68	-85.87	-89.71	-93.93	-94.23
64	-16.87	-41.65	-50.18	-51.87	-41.56	-41.82	-43.00	-84.56	-70.51	-86.27	-82.40	-95.32	-93.68	-93.51
65	-14.19	-38.39	-47.38	-38.23	-39.23	-39.78	-40.03	-74.52	-67.60	-81.39	-91.21	-90.10	-91.19	-94.04
66	-16.59	-43.68	-51.09	-51.64	-50.89	-42.38	-42.32	-87.04	-74.77	-75.90	-91.68	-91.08	-88.79	-90.98
67	-18.15	-39.34	-47.17	-49.90	-39.58	-41.62	-43.85	-75.87	-33.22	-74.78	-92.84	-92.28	-89.08	-90.81
68	-11.80	-39.45	-47.04	-48.53	-42.55	-41.70	-43.42	-79.78	-79.94	-73.68	-90.36	-94.06	-92.70	-92.07
69	-16.77	-39.42	-44.96	-38.91	-40.28	-41.13	-40.33	-83.95	-73.81	-80.57	-91.42	-93.38	-91.26	-87.42
70	-7.99	-38.50	-44.25	-32.87	-35.59	-35.57	-32.57	-66.64	-32.20	-84.41	-88.92	-90.53	-92.81	-93.52
71	-16.96	-39.27	-47.81	-50.61	-39.53	-41.13	-42.59	-84.42	-56.21	-74.11	-85.45	-91.57	-93.78	-93.12
72	-16.93	-41.53	-49.44	-49.38	-48.82	-41.99	-43.32	-78.09	-77.28	-79.94	-92.76	-95.91	-91.29	-93.86
73	-12.07	-42.00	-48.57	-50.55	-43.25	-42.93	-41.88	-66.21	-81.82	-67.20	-89.72	-44.88	-85.46	-92.34
74	-17.51	-37.64	-44.95	-47.23	-42.55	-43.69	-44.46	-85.75	-67.01	-84.81	-90.76	-90.48	-95.23	-95.24
75	-16.32	-44.49	-43.93	-36.54	-34.64	-35.19	-37.39	-77.76	-86.29	-86.55	-90.80	-85.53	-89.86	-92.76
76	-11.85	-37.37	-43.37	-40.96	-41.31	-41.65	-37.71	-76.65	-71.67	-87.84	-91.42	-93.24	-63.73	-91.04
77	-17.57	-40.53	-47.71	-52.09	-41.68	-40.12	-40.93	-81.10	-63.26	-86.44	-85.70	-92.01	-89.83	-91.55
78	-17.53	-43.85	-47.51	-36.44	-32.98	-33.83	-33.45	-78.96	-78.04	-69.36	-90.43	-86.03	-84.57	-93.13
79	-15.66	-38.70	-45.23	-38.51	-39.20	-40.72	-38.11	-84.60	-32.32	-83.42	-89.21	-87.04	-77.59	-91.72
80	-14.49	-35.90	-43.90	-47.61	-42.89	-43.24	-42.64	-72.61	-51.21	-84.07	-90.36	-89.71	-90.58	-93.40
81	-16.68	-39.88	-47.10	-46.49	-40.52	-42.64	-41.20	-78.05	-87.13	-82.02	-95.71	-88.82	-83.53	-94.27
82	-20.39	-41.41	-50.29	-52.04	-49.36	-46.79	-47.57	-84.93	-48.58	-60.84	-83.26	-88.49	-93.93	-92.64
83	-19.46	-40.68	-49.62	-50.79	-42.76	-43.35	-43.89	-82.87	-54.82	-79.66	-89.36	-93.12	-92.76	-94.61
84	-18.10	-42.21	-45.77	-38.17	-37.68	-37.47	-39.59	-88.72	-70.88	-81.51	-93.31	-89.71	-92.05	-93.27
85	-15.89	-42.23	-49.61	-51.25	-43.64	-40.39	-40.64	-73.16	-72.88	-86.65	-89.03	-94.35	-90.82	-95.19
86	-13.72	-41.01	-49.24	-50.73	-43.24	-44.19	-43.87	-81.86	-82.72	-72.49	-90.28	-91.35	-94.06	-89.27
87	-15.46	-43.21	-50.93	-50.17	-51.54	-46.87	-47.16	-65.06	-80.30	-82.92	-89.21	-94.00	-93.02	-93.72
88	-14.66	-39.04	-45.60	-37.70	-39.37	-39.63	-40.12	-80.30	-29.24	-79.68	-87.87	-92.75	-91.79	-89.65
89	-15.90	-42.73	-49.11	-50.25	-43.64	-44.86	-45.95	-84.48	-73.57	-73.86	-84.72	-92.55	-91.06	-91.25
90	-14.19	-42.07	-49.47	-38.74	-40.66	-41.70	-40.47	-59.67	-67.22	-75.30	-93.86	-93.86	-92.19	-92.92
91	-12.62	-40.02	-47.82	-46.93	-38.52	-37.37	-38.28	-69.64	-81.77	-67.92	-89.80	-75.42	-90.88	-92.01
92	-4.04	-34.65	-44.23	-46.30	-42.34	-43.89	-45.28	-60.86	-72.63	-90.94	-94.48	-91.97	-93.77	-95.43
93	-17.60	-44.25	-49.79	-52.40	-50.87	-46.41	-47.52	-85.34	-83.82	-69.69	-79.10	-95.06	-94.16	-93.76
94	-15.25	-43.69	-45.03	-47.36	-43.46	-44.74	-43.86	-82.56	-84.42	-78.99	-93.59	-93.38	-93.22	-87.87
95	-15.84	-37.95	-43.73	-37.47	-34.09	-34.40	-34.35	-82.28	-51.64	-84.42	-89.80	-82.68	-90.72	-93.25
96	-15.31	-38.05	-44.10	-48.75	-42.55	-36.57	-33.80	-76.39	-53.12	-87.30	-92.50	-92.72	-84.26	-89.38
97	-13.61	-42.05	-48.27	-50.80	-43.35	-45.06	-43.24	-71.48	-90.42	-87.03	-89.21	-92.38	-92.48	-87.83
98	-20.70	-46.92	-52.67	-55.36	-39.65	-37.77	-38.18	-84.69	-86.12	-86.69	-61.40	-88.38	-62.56	-92.21
99	-14.72	-36.61	-43.67	-38.06	-40.30	-42.63	-42.56	-68.20	-67.31	-91.07	-90.36	-93.78	-96.02	-91.99
100	-20.39	-41.50	-45.78	-50.73	-41.47	-41.83	-39.49	-83.76	-65.55	-86.38	-87.63	-92.55	-88.47	-80.41

Appendix Table B.7a Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 100 length measurements using the two partitions for grouping the European hake data.

	Sample size = 100 length measurements													
	Estimates													
	Birgè and Rozenholc algorithm													
	mean 1 (cm)	*mean 2 (cm)*	*mean 3 (cm)*	*mean 4 (cm)*	*mean 5 (cm)*	*mean 6 (cm)*	*mean 7 (cm)*	*SD 1 (cm)*	*SD 2 (cm)*	*SD 3 (cm)*	*SD 4 (cm)*	*SD 5 (cm)*	*SD 6 (cm)*	*SD 7 (cm)*
1	/	/	/	/	/	/	/	/	/	/	/	/	/	/
2	/	/	/	/	/	/	/	/	/	/	/	/	/	/
3	/	/	/	/	/	/	/	/	/	/	/	/	/	/
4	/	/	/	/	/	/	/	/	/	/	/	/	/	/
5	/	/	/	/	/	/	/	/	/	/	/	/	/	/
6	/	/	/	/	/	/	/	/	/	/	/	/	/	/
7	34.45	/	/	/	/	/	/	15.90	/	/	/	/	/	/
8	/	/	/	/	/	/	/	/	/	/	/	/	/	/
9	/	/	/	/	/	/	/	/	/	/	/	/	/	/
10	/	/	/	/	/	/	/	/	/	/	/	/	/	/
11	/	/	/	/	/	/	/	/	/	/	/	/	/	/
12	/	/	/	/	/	/	/	/	/	/	/	/	/	/
13	/	/	/	/	/	/	/	/	/	/	/	/	/	/
14	/	/	/	/	/	/	/	/	/	/	/	/	/	/
15	/	/	/	/	/	/	/	/	/	/	/	/	/	/
16	/	/	/	/	/	/	/	/	/	/	/	/	/	/
17	/	/	/	/	/	/	/	/	/	/	/	/	/	/
18	/	/	/	/	/	/	/	/	/	/	/	/	/	/
19	/	/	/	/	/	/	/	/	/	/	/	/	/	/
20	/	/	/	/	/	/	/	/	/	/	/	/	/	/
21	/	/	/	/	/	/	/	/	/	/	/	/	/	/
22	/	/	/	/	/	/	/	/	/	/	/	/	/	/
23	/	/	/	/	/	/	/	/	/	/	/	/	/	/
24	/	/	/	/	/	/	/	/	/	/	/	/	/	/
25	/	/	/	/	/	/	/	/	/	/	/	/	/	/
26	/	/	/	/	/	/	/	/	/	/	/	/	/	/
27	/	/	/	/	/	/	/	/	/	/	/	/	/	/
28	/	/	/	/	/	/	/	/	/	/	/	/	/	/
29	/	/	/	/	/	/	/	/	/	/	/	/	/	/
30	/	/	/	/	/	/	/	/	/	/	/	/	/	/
31	/	/	/	/	/	/	/	/	/	/	/	/	/	/
32	/	/	/	/	/	/	/	/	/	/	/	/	/	/
33	14.87175	/	/	/	/	/	/	15.22	/	/	/	/	/	/
34	/	/	/	/	/	/	/	/	/	/	/	/	/	/
35	/	/	/	/	/	/	/	/	/	/	/	/	/	/
36	/	/	/	/	/	/	/	/	/	/	/	/	/	/
37	/	/	/	/	/	/	/	/	/	/	/	/	/	/
38	/	/	/	/	/	/	/	/	/	/	/	/	/	/
39	/	/	/	/	/	/	/	/	/	/	/	/	/	/
40	/	/	/	/	/	/	/	/	/	/	/	/	/	/
41	/	/	/	/	/	/	/	/	/	/	/	/	/	/
42	/	/	/	/	/	/	/	/	/	/	/	/	/	/
43	/	/	/	/	/	/	/	/	/	/	/	/	/	/
44	31.77	/	/	/	/	/	/	10.69	/	/	/	/	/	/
45	/	/	/	/	/	/	/	/	/	/	/	/	/	/
46	20.66	/	/	/	/	/	/	13.85	/	/	/	/	/	/
47	27.60008	55.77	/	/	/	/	/	5.95	4.44	/	/	/	/	/
48	/	/	/	/	/	/	/	/	/	/	/	/	/	/
49	/	/	/	/	/	/	/	/	/	/	/	/	/	/
50	/	/	/	/	/	/	/	/	/	/	/	/	/	/
51	/	/	/	/	/	/	/	/	/	/	/	/	/	/
52	/	/	/	/	/	/	/	/	/	/	/	/	/	/
53	/	/	/	/	/	/	/	/	/	/	/	/	/	/
54	/	/	/	/	/	/	/	/	/	/	/	/	/	/
55	/	/	/	/	/	/	/	/	/	/	/	/	/	/
56	/	/	/	/	/	/	/	/	/	/	/	/	/	/
57	/	/	/	/	/	/	/	/	/	/	/	/	/	/
58	/	/	/	/	/	/	/	/	/	/	/	/	/	/
59	/	/	/	/	/	/	/	/	/	/	/	/	/	/
60	33.27	/	/	/	/	/	/	13.43	/	/	/	/	/	/
61	39.10	45.15314	/	/	/	/	/	12.66	4.98	/	/	/	/	/
62	28.43	37.46363	/	/	/	/	/	4.35	5.06	/	/	/	/	/
63	/	/	/	/	/	/	/	/	/	/	/	/	/	/
64	/	/	/	/	/	/	/	/	/	/	/	/	/	/
65	/	/	/	/	/	/	/	/	/	/	/	/	/	/
66	/	/	/	/	/	/	/	/	/	/	/	/	/	/
67	/	/	/	/	/	/	/	/	/	/	/	/	/	/
68	/	/	/	/	/	/	/	/	/	/	/	/	/	/
69	/	/	/	/	/	/	/	/	/	/	/	/	/	/
70	/	/	/	/	/	/	/	/	/	/	/	/	/	/
71	/	/	/	/	/	/	/	/	/	/	/	/	/	/
72	/	/	/	/	/	/	/	/	/	/	/	/	/	/
73	/	/	/	/	/	/	/	/	/	/	/	/	/	/
74	/	/	/	/	/	/	/	/	/	/	/	/	/	/
75	/	/	/	/	/	/	/	/	/	/	/	/	/	/
76	/	/	/	/	/	/	/	/	/	/	/	/	/	/
77	42.40	58.97	/	/	/	/	/	5.05	3.25	/	/	/	/	/
78	/	/	/	/	/	/	/	/	/	/	/	/	/	/
79	/	/	/	/	/	/	/	/	/	/	/	/	/	/
80	/	/	/	/	/	/	/	/	/	/	/	/	/	/
81	18.02	/	/	/	/	/	/	13.15	/	/	/	/	/	/
82	/	/	/	/	/	/	/	/	/	/	/	/	/	/
83	/	/	/	/	/	/	/	/	/	/	/	/	/	/
84	/	/	/	/	/	/	/	/	/	/	/	/	/	/
85	/	/	/	/	/	/	/	/	/	/	/	/	/	/
86	/	/	/	/	/	/	/	/	/	/	/	/	/	/
87	/	/	/	/	/	/	/	/	/	/	/	/	/	/
88	/	/	/	/	/	/	/	/	/	/	/	/	/	/
89	/	/	/	/	/	/	/	/	/	/	/	/	/	/
90	/	/	/	/	/	/	/	/	/	/	/	/	/	/
91	/	/	/	/	/	/	/	/	/	/	/	/	/	/
92	/	/	/	/	/	/	/	/	/	/	/	/	/	/
93	/	/	/	/	/	/	/	/	/	/	/	/	/	/
94	/	/	/	/	/	/	/	/	/	/	/	/	/	/
95	/	/	/	/	/	/	/	/	/	/	/	/	/	/
96	/	/	/	/	/	/	/	/	/	/	/	/	/	/
97	/	/	/	/	/	/	/	/	/	/	/	/	/	/
98	/	/	/	/	/	/	/	/	/	/	/	/	/	/
99	/	/	/	/	/	/	/	/	/	/	/	/	/	/
100	/	/	/	/	/	/	/	/	/	/	/	/	/	/

Appendix Table B.7b Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 100 length measurements using the two partitions for grouping the European hake data.

	Sample size = 100 length measurements													
	Estimates													
	2 cm													
	mean 1 (cm)	*mean 2 (cm)*	*mean 3 (cm)*	*mean 4 (cm)*	*mean 5 (cm)*	*mean 6 (cm)*	*mean 7 (cm)*	*SD 1 (cm)*	*SD 2 (cm)*	*SD 3 (cm)*	*SD 4 (cm)*	*SD 5 (cm)*	*SD 6 (cm)*	*SD 7 (cm)*
1	17.93	34.50	40.92	47.50	/	/	/	1.17	0.93	1.35	1.20	/	/	/
2	18.24	32.00	40.50	/	/	/	/	1.21	0.85	1.20	/	/	/	/
3	20.13	27.67	37.00	45.50	/	/	/	1.48	1.42	0.85	1.06	/	/	/
4	26.74	47.00	/	/	/	/	/	1.38	0.85	/	/	/	/	/
5	19.40	26.29	32.50	55.00	/	/	/	1.49	1.48	0.95	0.85	/	/	/
6	18.69	28.23	44.04	/	/	/	/	0.91	1.31	1.56	/	/	/	/
7	20.27	36.76	/	/	/	/	/	1.54	1.06	/	/	/	/	/
8	17.97	38.05	/	/	/	/	/	1.20	2.23	/	/	/	/	/
9	18.88	25.42	34.50	50.00	/	/	/	1.42	1.17	0.98	0.60	/	/	/
10	26.03	36.20	/	/	/	/	/	1.20	1.47	/	/	/	/	/
11	19.50	25.31	36.18	42.00	/	/	/	1.00	1.20	2.28	0.60	/	/	/
12	20.19	24.50	40.01	/	/	/	/	1.30	0.83	1.19	/	/	/	/
13	19.36	26.16	33.50	49.50	52.00	/	/	1.03	1.09	0.98	1.06	0.67	/	/
14	18.71	28.43	40.50	57.50	/	/	/	1.11	1.22	0.98	1.20	/	/	/
15	18.24	26.21	30.68	39.00	/	/	/	1.06	1.51	1.01	0.85	/	/	/
16	19.37	28.50	/	/	/	/	/	1.15	1.35	/	/	/	/	/
17	18.37	26.50	35.14	50.00	/	/	/	1.23	0.79	0.63	0.60	/	/	/
18	18.36	27.00	35.00	45.73	/	/	/	1.01	2.07	0.85	1.29	/	/	/
19	27.35	31.04	/	/	/	/	/	1.06	1.11	/	/	/	/	/
20	18.82	26.91	33.50	47.00	/	/	/	1.72	1.00	0.95	0.85	/	/	/
21	19.13	25.67	34.50	/	/	/	/	0.83	2.11	1.20	/	/	/	/
22	18.83	27.66	47.34	/	/	/	/	1.06	1.10	1.62	/	/	/	/
23	22.00	26.62	33.98	/	/	/	/	0.85	1.31	0.97	/	/	/	/
24	17.89	31.79	41.50	/	/	/	/	1.84	1.11	0.95	/	/	/	/
25	19.45	28.30	34.50	/	/	/	/	1.27	2.11	1.06	/	/	/	/
26	18.13	29.50	36.50	/	/	/	/	0.83	1.35	1.06	/	/	/	/
27	18.50	28.50	33.21	/	/	/	/	0.84	0.83	1.11	/	/	/	/
28	18.64	27.52	36.23	/	/	/	/	1.01	1.59	0.82	/	/	/	/
29	18.98	31.58	38.11	56.91	49.11	/	/	0.98	1.63	1.24	4.06	1.03	/	/
30	20.11	25.89	35.00	/	/	/	/	0.96	1.15	0.85	/	/	/	/
31	19.12	27.73	36.25	42.91	/	/	/	1.05	1.18	1.35	1.86	/	/	/
32	18.93	26.50	34.73	/	/	/	/	1.18	1.58	1.00	/	/	/	/
33	19.07	26.61	38.27	/	/	/	/	0.93	1.39	1.27	/	/	/	/
34	18.50	28.39	35.50	/	/	/	/	0.84	1.84	1.06	/	/	/	/
35	19.18	26.16	36.08	/	/	/	/	1.32	1.20	1.35	/	/	/	/
36	18.99	25.17	34.27	/	/	/	/	0.95	0.95	1.00	/	/	/	/
37	19.09	29.33	44.01	48.00	/	/	/	1.38	0.77	1.90	0.85	/	/	/
38	18.29	26.15	34.96	46.14	/	/	/	0.95	1.35	1.15	3.03	/	/	/
39	19.50	26.23	37.00	/	/	/	/	0.91	0.89	0.60	/	/	/	/
40	26.40	30.62	42.50	/	/	/	/	1.32	1.67	1.06	/	/	/	/
41	25.70	30.73	34.50	45.17	/	/	/	0.93	1.29	0.90	0.69	/	/	/
42	19.50	32.53	44.78	/	/	/	/	1.05	1.62	2.22	/	/	/	/
43	19.46	34.00	46.65	/	/	/	/	1.39	0.85	2.13	/	/	/	/
44	18.01	44.50	/	/	/	/	/	1.62	1.57	/	/	/	/	/
45	18.52	26.94	42.00	45.23	51.00	/	/	1.55	1.62	0.67	0.82	0.60	/	/
46	18.78	28.32	41.50	/	/	/	/	1.41	1.14	1.20	/	/	/	/
47	27.34	/	/	/	/	/	/	1.35	/	/	/	/	/	/
48	18.91	25.50	34.17	/	/	/	/	1.00	1.11	0.69	/	/	/	/
49	25.76	28.73	33.11	48.39	/	/	/	1.06	1.20	1.03	2.16	/	/	/
50	17.95	25.91	34.24	/	/	/	/	1.84	1.49	1.06	/	/	/	/
51	18.21	31.29	58.00	/	/	/	/	1.50	0.95	0.85	/	/	/	/
52	18.64	36.96	47.73	/	/	/	/	1.11	1.15	1.29	/	/	/	/
53	18.79	26.50	/	/	/	/	/	1.31	1.11	/	/	/	/	/
54	19.10	26.50	35.27	41.50	/	/	/	0.97	0.90	1.51	1.06	/	/	/
55	18.50	27.29	44.50	/	/	/	/	0.78	0.95	1.06	/	/	/	/
56	19.57	32.50	35.50	41.69	/	/	/	1.17	0.98	1.06	0.90	/	/	/
57	19.17	26.50	34.50	42.00	/	/	/	1.84	1.40	0.85	0.85	/	/	/
58	18.87	26.80	35.23	44.23	/	/	/	2.12	1.51	0.82	0.82	/	/	/
59	27.11	30.76	34.24	51.50	/	/	/	1.70	1.37	1.06	1.06	/	/	/
60	18.47	31.00	/	/	/	/	/	1.11	0.67	/	/	/	/	/
61	20.11	27.66	41.50	49.50	52.00	/	/	1.29	1.35	1.10	1.57	1.11	/	/
62	19.25	32.87	37.50	44.00	/	/	/	1.04	0.95	1.70	0.67	/	/	/
63	18.05	26.24	34.49	/	/	/	/	0.95	1.11	1.46	/	/	/	/
64	17.54	28.90	48.00	/	/	/	/	1.96	1.09	0.67	/	/	/	/
65	18.81	26.83	37.50	44.50	/	/	/	1.00	0.95	0.93	1.20	/	/	/
66	19.87	26.50	35.29	/	/	/	/	1.03	1.20	2.11	/	/	/	/
67	19.61	34.50	39.34	42.00	/	/	/	1.54	1.06	1.29	0.85	/	/	/
68	18.63	25.50	42.56	/	/	/	/	1.32	1.21	1.69	/	/	/	/
69	19.72	25.87	35.50	/	/	/	/	1.07	1.26	1.20	/	/	/	/
70	19.26	32.50	36.50	53.50	/	/	/	0.81	1.06	0.95	1.70	/	/	/
71	18.74	27.46	31.04	42.00	/	/	/	0.81	1.81	1.11	0.85	/	/	/
72	25.33	28.41	41.44	/	/	/	/	1.11	1.22	1.70	/	/	/	/
73	24.91	28.45	34.04	46.44	51.91	/	/	1.86	1.25	1.15	1.70	1.86	/	/
74	24.84	28.65	40.84	47.00	/	/	/	1.09	0.81	1.09	0.85	/	/	/
75	19.06	30.50	38.50	47.82	/	/	/	1.10	1.35	1.06	1.29	/	/	/
76	32.30	37.25	/	/	/	/	/	1.69	1.43	/	/	/	/	/
77	26.57	32.67	35.08	42.38	/	/	/	1.53	0.86	1.35	1.72	/	/	/
78	18.23	27.18	42.84	/	/	/	/	1.03	0.93	1.47	/	/	/	/
79	19.34	26.88	41.04	/	/	/	/	1.65	1.08	1.15	/	/	/	/
80	19.23	30.00	39.00	/	/	/	/	0.93	1.11	0.67	/	/	/	/
81	19.14	28.00	38.50	41.00	/	/	/	0.97	0.85	1.06	0.60	/	/	/
82	21.35	27.36	45.50	/	/	/	/	2.13	0.84	1.20	/	/	/	/
83	19.30	28.89	35.50	/	/	/	/	0.93	2.01	1.70	/	/	/	/
84	19.82	25.93	34.34	43.33	/	/	/	1.17	1.42	1.29	0.77	/	/	/
85	19.21	27.09	/	/	/	/	/	1.49	1.76	/	/	/	/	/
86	19.45	27.30	32.24	/	/	/	/	1.73	1.41	1.06	/	/	/	/
87	25.07	28.18	33.69	/	/	/	/	1.57	2.32	1.20	/	/	/	/
88	19.18	25.66	34.50	43.95	/	/	/	0.83	0.83	1.06	1.49	/	/	/
89	18.97	27.62	34.50	42.00	/	/	/	0.97	0.93	1.06	0.49	/	/	/
90	18.35	27.21	36.12	45.00	/	/	/	1.02	0.90	1.65	0.85	/	/	/
91	19.71	27.89	51.85	/	/	/	/	1.15	0.92	1.11	/	/	/	/
92	19.39	28.28	34.50	/	/	/	/	1.26	1.26	1.06	/	/	/	/
93	18.50	28.28	39.21	50.50	/	/	/	1.47	1.29	1.11	1.70	/	/	/
94	19.00	31.79	36.08	/	/	/	/	0.97	1.11	1.35	/	/	/	/
95	20.02	26.32	35.53	42.25	/	/	/	1.25	1.14	1.62	1.80	/	/	/
96	19.05	30.67	34.84	/	/	/	/	1.18	0.86	2.39	/	/	/	/
97	19.92	28.28	46.24	/	/	/	/	1.04	1.29	1.06	/	/	/	/
98	18.81	26.57	39.50	42.00	/	/	/	1.01	1.35	1.06	0.85	/	/	/
99	19.00	26.34	34.21	49.00	/	/	/	0.74	0.83	1.63	0.85	/	/	/
100	19.82	26.24	51.17	/	/	/	/	0.97	1.26	1.20	/	/	/	/

Appendix Table B.7c Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 100 length measurements using the two partitions for grouping the European hake data.

	Sample size = 100 length measurements													
	% Bias													
	Birgè and Rozenholc algorithm													
	mean 1	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*mean 7*	*SD 1*	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*	*SD 7*
1	/	/	/	/	/	/	/	/	/	/	/	/	/	/
2	/	/	/	/	/	/	/	/	/	/	/	/	/	/
3	/	/	/	/	/	/	/	/	/	/	/	/	/	/
4	/	/	/	/	/	/	/	/	/	/	/	/	/	/
5	/	/	/	/	/	/	/	/	/	/	/	/	/	/
6	/	/	/	/	/	/	/	/	/	/	/	/	/	/
7	77.65	/	/	/	/	/	/	1004.18	/	/	/	/	/	/
8	/	/	/	/	/	/	/	/	/	/	/	/	/	/
9	/	/	/	/	/	/	/	/	/	/	/	/	/	/
10	/	/	/	/	/	/	/	/	/	/	/	/	/	/
11	/	/	/	/	/	/	/	/	/	/	/	/	/	/
12	/	/	/	/	/	/	/	/	/	/	/	/	/	/
13	/	/	/	/	/	/	/	/	/	/	/	/	/	/
14	/	/	/	/	/	/	/	/	/	/	/	/	/	/
15	/	/	/	/	/	/	/	/	/	/	/	/	/	/
16	/	/	/	/	/	/	/	/	/	/	/	/	/	/
17	/	/	/	/	/	/	/	/	/	/	/	/	/	/
18	/	/	/	/	/	/	/	/	/	/	/	/	/	/
19	/	/	/	/	/	/	/	/	/	/	/	/	/	/
20	/	/	/	/	/	/	/	/	/	/	/	/	/	/
21	/	/	/	/	/	/	/	/	/	/	/	/	/	/
22	/	/	/	/	/	/	/	/	/	/	/	/	/	/
23	/	/	/	/	/	/	/	/	/	/	/	/	/	/
24	/	/	/	/	/	/	/	/	/	/	/	/	/	/
25	/	/	/	/	/	/	/	/	/	/	/	/	/	/
26	/	/	/	/	/	/	/	/	/	/	/	/	/	/
27	/	/	/	/	/	/	/	/	/	/	/	/	/	/
28	/	/	/	/	/	/	/	/	/	/	/	/	/	/
29	/	/	/	/	/	/	/	/	/	/	/	/	/	/
30	/	/	/	/	/	/	/	/	/	/	/	/	/	/
31	/	/	/	/	/	/	/	/	/	/	/	/	/	/
32	/	/	/	/	/	/	/	/	/	/	/	/	/	/
33	-23.30197	/	/	/	/	/	/	956.6028	/	/	/	/	/	/
34	/	/	/	/	/	/	/	/	/	/	/	/	/	/
35	/	/	/	/	/	/	/	/	/	/	/	/	/	/
36	/	/	/	/	/	/	/	/	/	/	/	/	/	/
37	/	/	/	/	/	/	/	/	/	/	/	/	/	/
38	/	/	/	/	/	/	/	/	/	/	/	/	/	/
39	/	/	/	/	/	/	/	/	/	/	/	/	/	/
40	/	/	/	/	/	/	/	/	/	/	/	/	/	/
41	/	/	/	/	/	/	/	/	/	/	/	/	/	/
42	/	/	/	/	/	/	/	/	/	/	/	/	/	/
43	/	/	/	/	/	/	/	/	/	/	/	/	/	/
44	63.87	/	/	/	/	/	/	642.21	/	/	/	/	/	/
45	/	/	/	/	/	/	/	/	/	/	/	/	/	/
46	6.56	/	/	/	/	/	/	861.57	/	/	/	/	/	/
47	42.34184	105.9345	/	/	/	/	/	313.182	129.0432	/	/	/	/	/
48	/	/	/	/	/	/	/	/	/	/	/	/	/	/
49	/	/	/	/	/	/	/	/	/	/	/	/	/	/
50	/	/	/	/	/	/	/	/	/	/	/	/	/	/
51	/	/	/	/	/	/	/	/	/	/	/	/	/	/
52	/	/	/	/	/	/	/	/	/	/	/	/	/	/
53	/	/	/	/	/	/	/	/	/	/	/	/	/	/
54	/	/	/	/	/	/	/	/	/	/	/	/	/	/
55	/	/	/	/	/	/	/	/	/	/	/	/	/	/
56	/	/	/	/	/	/	/	/	/	/	/	/	/	/
57	/	/	/	/	/	/	/	/	/	/	/	/	/	/
58	/	/	/	/	/	/	/	/	/	/	/	/	/	/
59	/	/	/	/	/	/	/	/	/	/	/	/	/	/
60	71.56	/	/	/	/	/	/	832.46	/	/	/	/	/	/
61	101.66	66.73981	/	/	/	/	/	778.82	156.8401	/	/	/	/	/
62	46.63	38.34427	/	/	/	/	/	202.23	160.764	/	/	/	/	/
63	/	/	/	/	/	/	/	/	/	/	/	/	/	/
64	/	/	/	/	/	/	/	/	/	/	/	/	/	/
65	/	/	/	/	/	/	/	/	/	/	/	/	/	/
66	/	/	/	/	/	/	/	/	/	/	/	/	/	/
67	/	/	/	/	/	/	/	/	/	/	/	/	/	/
68	/	/	/	/	/	/	/	/	/	/	/	/	/	/
69	/	/	/	/	/	/	/	/	/	/	/	/	/	/
70	/	/	/	/	/	/	/	/	/	/	/	/	/	/
71	/	/	/	/	/	/	/	/	/	/	/	/	/	/
72	/	/	/	/	/	/	/	/	/	/	/	/	/	/
73	/	/	/	/	/	/	/	/	/	/	/	/	/	/
74	/	/	/	/	/	/	/	/	/	/	/	/	/	/
75	/	/	/	/	/	/	/	/	/	/	/	/	/	/
76	/	/	/	/	/	/	/	/	/	/	/	/	/	/
77	118.68	117.7698	/	/	/	/	/	250.83	67.48819	/	/	/	/	/
78	/	/	/	/	/	/	/	/	/	/	/	/	/	/
79	/	/	/	/	/	/	/	/	/	/	/	/	/	/
80	/	/	/	/	/	/	/	/	/	/	/	/	/	/
81	-7.06	/	/	/	/	/	/	813.09	/	/	/	/	/	/
82	/	/	/	/	/	/	/	/	/	/	/	/	/	/
83	/	/	/	/	/	/	/	/	/	/	/	/	/	/
84	/	/	/	/	/	/	/	/	/	/	/	/	/	/
85	/	/	/	/	/	/	/	/	/	/	/	/	/	/
86	/	/	/	/	/	/	/	/	/	/	/	/	/	/
87	/	/	/	/	/	/	/	/	/	/	/	/	/	/
88	/	/	/	/	/	/	/	/	/	/	/	/	/	/
89	/	/	/	/	/	/	/	/	/	/	/	/	/	/
90	/	/	/	/	/	/	/	/	/	/	/	/	/	/
91	/	/	/	/	/	/	/	/	/	/	/	/	/	/
92	/	/	/	/	/	/	/	/	/	/	/	/	/	/
93	/	/	/	/	/	/	/	/	/	/	/	/	/	/
94	/	/	/	/	/	/	/	/	/	/	/	/	/	/
95	/	/	/	/	/	/	/	/	/	/	/	/	/	/
96	/	/	/	/	/	/	/	/	/	/	/	/	/	/
97	/	/	/	/	/	/	/	/	/	/	/	/	/	/
98	/	/	/	/	/	/	/	/	/	/	/	/	/	/
99	/	/	/	/	/	/	/	/	/	/	/	/	/	/
100	/	/	/	/	/	/	/	/	/	/	/	/	/	/

Appendix Table B.7d Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 100 length measurements using the two partitions for grouping the European hake data.

	Sample size = 100 length measurements													
	% Bias													
	2 cm													
	mean 1	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*mean 7*	*SD 1*	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*	*SD 7*
1	-7.55	27.40	24.38	19.11	/	/	/	-18.59	-51.96	-41.84	-56.79	/	/	/
2	-5.94	18.17	23.10	/	/	/	/	-15.73	-56.22	-48.23	/	/	/	/
3	3.79	2.17	12.46	14.09	/	/	/	2.44	-26.75	-63.39	-62.00	/	/	/
4	37.88	73.56	/	/	/	/	/	-4.15	-56.22	/	/	/	/	/
5	0.03	-2.91	-1.22	37.91	/	/	/	3.25	-23.85	-58.88	-69.45	/	/	/
6	-3.61	4.26	33.86	/	/	/	/	-37.02	-32.66	-32.59	/	/	/	/
7	4.56	35.74	/	/	/	/	/	6.69	-45.54	/	/	/	/	/
8	-7.31	40.49	/	/	/	/	/	-16.59	15.07	/	/	/	/	/
9	-2.65	-6.12	4.86	25.38	/	/	/	-1.16	-39.77	-57.73	-78.40	/	/	/
10	34.24	33.68	/	/	/	/	/	-16.59	-24.17	/	/	/	/	/
11	0.57	-6.55	9.97	5.32	/	/	/	-30.42	-38.09	-1.69	-78.40	/	/	/
12	4.12	-9.53	21.60	/	/	/	/	-9.42	-57.12	-48.89	/	/	/	/
13	-0.17	-3.41	1.82	24.12	10.31	/	/	-28.70	-43.66	-57.73	-62.00	-79.24	/	/
14	-3.52	4.98	23.10	44.18	/	/	/	-23.21	-37.36	-57.73	-56.79	/	/	/
15	-5.92	-3.21	-6.73	-2.21	/	/	/	-26.63	-22.11	-56.61	-69.45	/	/	/
16	-0.09	5.24	/	/	/	/	/	-19.92	-30.45	/	/	/	/	/
17	-5.27	-2.14	6.80	25.38	/	/	/	-14.78	-59.11	-72.88	-78.40	/	/	/
18	-5.31	-0.31	6.38	14.67	/	/	/	-29.60	6.57	-63.39	-53.45	/	/	/
19	41.04	14.64	/	/	/	/	/	-26.05	-42.54	/	/	/	/	/
20	-2.95	-0.64	1.82	17.85	/	/	/	19.32	-48.64	-58.88	-69.45	/	/	/
21	-1.35	-5.20	4.86	/	/	/	/	-42.23	8.59	-48.23	/	/	/	/
22	-2.87	2.15	43.89	/	/	/	/	-26.63	-43.36	-30.37	/	/	/	/
23	13.46	-1.71	3.29	/	/	/	/	-41.02	-32.60	-58.14	/	/	/	/
24	-7.74	17.38	26.14	/	/	/	/	28.10	-42.54	-58.88	/	/	/	/
25	0.29	4.52	4.86	/	/	/	/	-11.52	8.82	-54.46	/	/	/	/
26	-6.50	8.94	10.94	/	/	/	/	-42.23	-30.45	-54.46	/	/	/	/
27	-4.59	5.24	0.95	/	/	/	/	-41.95	-57.12	-51.95	/	/	/	/
28	-3.87	1.62	10.12	/	/	/	/	-29.60	-18.17	-64.85	/	/	/	/
29	-2.13	16.61	15.85	42.69	4.19	/	/	-32.25	-15.94	-46.49	45.91	-68.41	/	/
30	3.74	-4.41	6.38	/	/	/	/	-33.13	-40.56	-63.39	/	/	/	/
31	-1.41	2.39	10.18	7.60	/	/	/	-27.05	-39.17	-41.95	-32.93	/	/	/
32	-2.39	-2.14	5.56	/	/	/	/	-18.02	-18.42	-57.06	/	/	/	/
33	-1.66	-1.74	16.32	/	/	/	/	-35.59	-28.53	-45.31	/	/	/	/
34	-4.59	4.85	7.90	/	/	/	/	-41.95	-4.96	-54.46	/	/	/	/
35	-1.06	-3.41	9.66	/	/	/	/	-8.50	-37.89	-41.84	/	/	/	/
36	-2.04	-7.05	4.17	/	/	/	/	-33.91	-51.22	-57.06	/	/	/	/
37	-1.53	8.30	33.77	20.36	/	/	/	-4.25	-60.16	-18.01	-69.45	/	/	/
38	-5.67	-3.42	6.26	15.70	/	/	/	-33.75	-30.34	-50.30	8.96	/	/	/
39	0.57	-3.16	12.46	/	/	/	/	-36.87	-54.13	-74.11	/	/	/	/
40	36.15	13.09	29.18	/	/	/	/	-8.65	-13.81	-54.46	/	/	/	/
41	32.55	13.49	4.86	13.26	/	/	/	-35.28	-33.30	-61.33	-75.06	/	/	/
42	0.57	20.14	36.11	/	/	/	/	-27.25	-16.30	-4.27	/	/	/	/
43	0.35	25.55	41.81	/	/	/	/	-3.21	-56.22	-8.05	/	/	/	/
44	-7.11	64.33	/	/	/	/	/	12.50	-19.05	/	/	/	/	/
45	-4.49	-0.51	27.66	13.42	8.19	/	/	7.48	-16.46	-70.92	-70.67	-81.52	/	/
46	-3.13	4.60	26.14	/	/	/	/	-1.86	-41.27	-48.23	/	/	/	/
47	41.01	/	/	/	/	/	/	-6.30	/	/	/	/	/	/
48	-2.49	-5.83	3.85	/	/	/	/	-30.81	-42.54	-70.11	/	/	/	/
49	32.84	6.08	0.65	21.33	/	/	/	-26.63	-38.09	-55.74	-22.40	/	/	/
50	-7.42	-4.30	4.08	/	/	/	/	27.47	-23.07	-54.46	/	/	/	/
51	-6.08	15.55	76.29	/	/	/	/	3.89	-50.82	-63.39	/	/	/	/
52	-3.87	36.49	45.08	/	/	/	/	-22.59	-40.56	-44.23	/	/	/	/
53	-3.08	-2.14	/	/	/	/	/	-8.94	-42.54	/	/	/	/	/
54	-1.50	-2.14	7.22	4.06	/	/	/	-32.53	-53.76	-34.85	-62.00	/	/	/
55	-4.59	0.77	35.26	/	/	/	/	-45.90	-50.82	-54.46	/	/	/	/
56	0.94	20.01	7.90	4.53	/	/	/	-19.05	-49.45	-54.46	-67.73	/	/	/
57	-1.13	-2.14	4.86	5.32	/	/	/	27.78	-27.88	-63.39	-69.45	/	/	/
58	-2.69	-1.03	7.08	10.91	/	/	/	47.28	-22.09	-64.85	-70.67	/	/	/
59	39.81	13.58	4.08	29.14	/	/	/	17.96	-29.62	-54.46	-62.00	/	/	/
60	-4.74	14.48	/	/	/	/	/	-22.59	-65.23	/	/	/	/	/
61	3.70	2.14	26.14	24.12	10.31	/	/	-10.50	-30.45	-52.66	-43.51	-65.83	/	/
62	-0.73	21.38	13.98	10.33	/	/	/	-27.45	-50.82	-26.78	-75.73	/	/	/
63	-6.89	-3.09	4.84	/	/	/	/	-33.93	-42.61	-37.18	/	/	/	/
64	-9.57	6.73	45.90	/	/	/	/	36.08	-43.97	-70.92	/	/	/	/
65	-2.98	-0.93	13.98	11.58	/	/	/	-30.81	-51.22	-59.83	-56.79	/	/	/
66	2.48	-2.14	7.25	/	/	/	/	-28.70	-38.09	-9.27	/	/	/	/
67	1.15	27.40	19.57	5.32	/	/	/	6.86	-45.54	-44.23	-69.45	/	/	/
68	-3.92	-5.83	29.37	/	/	/	/	-8.32	-37.45	-27.01	/	/	/	/
69	1.70	-4.47	7.90	/	/	/	/	-26.04	-34.87	-48.23	/	/	/	/
70	-0.67	20.01	10.94	34.15	/	/	/	-43.71	-45.54	-58.88	-38.90	/	/	/
71	-3.35	1.39	-5.64	5.32	/	/	/	-43.71	-6.73	-51.95	-69.45	/	/	/
72	30.64	4.93	25.97	/	/	/	/	-22.59	-37.10	-26.78	/	/	/	/
73	28.47	5.06	3.46	16.46	10.12	/	/	29.47	-35.54	-50.30	-38.90	-42.63	/	/
74	28.13	5.80	24.15	17.85	/	/	/	-24.09	-58.22	-52.89	-69.45	/	/	/
75	-1.71	12.63	17.02	19.91	/	/	/	-23.73	-30.45	-54.46	-53.45	/	/	/
76	66.60	37.56	/	/	/	/	/	17.49	-26.23	/	/	/	/	/
77	37.01	20.64	6.62	6.26	/	/	/	6.12	-55.70	-41.84	-38.10	/	/	/
78	-5.98	0.38	30.22	/	/	/	/	-28.70	-51.96	-36.70	/	/	/	/
79	-0.24	-0.75	24.74	/	/	/	/	14.63	-44.46	-50.30	/	/	/	/
80	-0.81	10.78	18.54	/	/	/	/	-35.14	-42.76	-70.92	/	/	/	/
81	-1.29	3.40	17.02	2.81	/	/	/	-32.75	-56.22	-54.46	-78.40	/	/	/
82	10.08	1.02	38.30	/	/	/	/	48.15	-56.54	-48.23	/	/	/	/
83	-0.46	6.67	7.90	/	/	/	/	-35.39	3.38	-26.78	/	/	/	/
84	2.21	-4.25	4.38	8.65	/	/	/	-18.54	-26.62	-44.23	-72.20	/	/	/
85	-0.94	0.03	/	/	/	/	/	3.68	-9.15	/	/	/	/	/
86	0.31	0.83	-2.00	/	/	/	/	19.99	-27.49	-54.46	/	/	/	/
87	29.29	4.05	2.42	/	/	/	/	9.06	19.43	-48.23	/	/	/	/
88	-1.08	-5.24	4.86	10.21	/	/	/	-42.23	-57.12	-54.46	-46.25	/	/	/
89	-2.17	1.98	4.86	5.32	/	/	/	-32.53	-51.96	-54.46	-82.36	/	/	/
90	-5.37	0.46	9.79	12.84	/	/	/	-28.93	-53.76	-28.77	-69.45	/	/	/
91	1.63	3.00	57.61	/	/	/	/	-19.92	-52.46	-52.13	/	/	/	/
92	0.02	4.45	4.86	/	/	/	/	-12.26	-34.87	-54.46	/	/	/	/
93	-4.59	4.41	19.19	26.63	/	/	/	2.15	-33.56	-51.95	-38.90	/	/	/
94	-2.03	17.38	9.66	/	/	/	/	-32.68	-42.54	-41.84	/	/	/	/
95	3.27	-2.79	8.01	5.94	/	/	/	-13.23	-41.27	-30.01	-35.19	/	/	/
96	-1.75	13.26	5.90	/	/	/	/	-17.72	-55.70	2.90	/	/	/	/
97	2.74	4.41	40.55	/	/	/	/	-27.92	-33.56	-54.46	/	/	/	/
98	-2.99	-1.90	20.06	5.32	/	/	/	-30.10	-30.40	-54.46	-69.45	/	/	/
99	-2.01	-2.73	3.99	22.87	/	/	/	-48.70	-57.12	-29.66	-69.45	/	/	/
100	2.20	-3.11	55.52	/	/	/	/	-32.52	-34.87	-48.23	/	/	/	/

Appendix Table B.8a Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 200 length measurements using the two partitions for grouping the European hake data.

Sample size = 200 length measurements														
Estimates														
Birgè and Rozenholc algorithm														
	mean 1 (cm)	*mean 2 (cm)*	*mean 3 (cm)*	*mean 4 (cm)*	*mean 5 (cm)*	*mean 6 (cm)*	*mean 7 (cm)*	*SD 1 (cm)*	*SD 2 (cm)*	*SD 3 (cm)*	*SD 4 (cm)*	*SD 5 (cm)*	*SD 6 (cm)*	*SD 7 (cm)*
1	/	/	/	/	/	/	/	/	/	/	/	/	/	/
2	/	/	/	/	/	/	/	/	/	/	/	/	/	/
3	/	/	/	/	/	/	/	/	/	/	/	/	/	/
4	/	/	/	/	/	/	/	/	/	/	/	/	/	/
5	5.16	7.01	9.55	/	/	/	/	0.54	1.42	0.94	/	/	/	/
6	5.36	9.54	/	/	/	/	/	1.11	0.92	/	/	/	/	/
7	/	/	/	/	/	/	/	/	/	/	/	/	/	/
8	5.65	8.02	9.71	/	/	/	/	0.82	0.91	1.01	/	/	/	/
9	3.90	/	/	/	/	/	/	2.77	/	/	/	/	/	/
10	/	/	/	/	/	/	/	/	/	/	/	/	/	/
11	5.64	7.30	10.53	/	/	/	/	1.19	4.21	1.08	/	/	/	/
12	/	/	/	/	/	/	/	/	/	/	/	/	/	/
13	5.65	/	/	/	/	/	/	2.31	/	/	/	/	/	/
14	/	/	/	/	/	/	/	/	/	/	/	/	/	/
15	4.18	/	/	/	/	/	/	2.51	/	/	/	/	/	/
16	5.65	10.05	12.35	/	/	/	/	1.18	0.63	0.54	/	/	/	/
17	6.11	10.02	/	/	/	/	/	1.41	1.27	/	/	/	/	/
18	5.31	6.91	10.48	/	/	/	/	0.92	1.40	0.93	/	/	/	/
19	/	/	/	/	/	/	/	/	/	/	/	/	/	/
20	/	/	/	/	/	/	/	/	/	/	/	/	/	/
21	/	/	/	/	/	/	/	/	/	/	/	/	/	/
22	/	/	/	/	/	/	/	/	/	/	/	/	/	/
23	/	/	/	/	/	/	/	/	/	/	/	/	/	/
24	4.79	6.44	8.80	11.74	/	/	/	0.89	0.90	1.02	0.68	/	/	/
25	/	/	/	/	/	/	/	/	/	/	/	/	/	/
26	5.47	8.18	/	/	/	/	/	1.23	1.66	/	/	/	/	/
27	4.95	6.61	/	/	/	/	/	0.43	0.94	/	/	/	/	/
28	5.39	7.59	11.16	/	/	/	/	2.67	1.73	1.27	/	/	/	/
29	6.07	9.41	/	/	/	/	/	1.43	1.36	/	/	/	/	/
30	/	/	/	/	/	/	/	/	/	/	/	/	/	/
31	/	/	/	/	/	/	/	/	/	/	/	/	/	/
32	4.00	6.06	7.76	9.49	/	/	/	0.51	0.70	0.68	0.97	/	/	/
33	5.14	9.57	/	/	/	/	/	1.16	1.24	/	/	/	/	/
34	5.68	8.44	/	/	/	/	/	1.56	2.53	/	/	/	/	/
35	/	/	/	/	/	/	/	/	/	/	/	/	/	/
36	3.91	5.81	7.73	9.33	11.92	/	/	0.52	1.06	1.43	0.88	0.72	/	/
37	/	/	/	/	/	/	/	/	/	/	/	/	/	/
38	5.74	9.63	/	/	/	/	/	1.13	1.72	/	/	/	/	/
39	5.73	9.16	/	/	/	/	/	1.79	1.79	/	/	/	/	/
40	5.38	8.79	/	/	/	/	/	1.49	1.33	/	/	/	/	/
41	/	/	/	/	/	/	/	/	/	/	/	/	/	/
42	4.93	10.66	/	/	/	/	/	1.61	1.32	/	/	/	/	/
43	5.69	9.28	/	/	/	/	/	0.94	1.03	/	/	/	/	/
44	5.64	9.77	/	/	/	/	/	1.45	1.52	/	/	/	/	/
45	/	/	/	/	/	/	/	/	/	/	/	/	/	/
46	/	/	/	/	/	/	/	/	/	/	/	/	/	/
47	/	/	/	/	/	/	/	/	/	/	/	/	/	/
48	5.67	/	/	/	/	/	/	1.24	/	/	/	/	/	/
49	5.41	7.47	9.30	/	/	/	/	0.87	1.01	0.91	/	/	/	/
50	/	/	/	/	/	/	/	/	/	/	/	/	/	/
51	5.42	9.24	11.57	/	/	/	/	0.74	0.58	0.81	/	/	/	/
52	/	/	/	/	/	/	/	/	/	/	/	/	/	/
53	5.70	8.76	/	/	/	/	/	1.64	1.32	/	/	/	/	/
54	/	/	/	/	/	/	/	/	/	/	/	/	/	/
55	5.46	7.29	10.88	/	/	/	/	1.00	1.51	1.22	/	/	/	/
56	5.58	9.27	/	/	/	/	/	1.07	1.32	/	/	/	/	/
57	/	/	/	/	/	/	/	/	/	/	/	/	/	/
58	5.22	7.69	/	/	/	/	/	1.25	1.44	/	/	/	/	/
59	5.18	6.63	7.73	11.35	/	/	/	0.71	1.02	0.76	0.81	/	/	/
60	/	/	/	/	/	/	/	/	/	/	/	/	/	/
61	3.92	5.50	9.06	11.61	/	/	/	0.47	0.61	0.87	0.65	/	/	/
62	5.37	9.02	/	/	/	/	/	2.15	1.57	/	/	/	/	/
63	5.69	8.80	/	/	/	/	/	1.37	1.87	/	/	/	/	/
64	/	/	/	/	/	/	/	/	/	/	/	/	/	/
65	5.53	6.01	9.68	/	/	/	/	1.04	1.36	0.92	/	/	/	/
66	5.61	10.38	/	/	/	/	/	1.10	0.83	/	/	/	/	/
67	/	/	/	/	/	/	/	/	/	/	/	/	/	/
68	/	/	/	/	/	/	/	/	/	/	/	/	/	/
69	/	/	/	/	/	/	/	/	/	/	/	/	/	/
70	5.58	11.21	/	/	/	/	/	0.90	1.08	/	/	/	/	/
71	5.45	8.23	11.29	/	/	/	/	0.93	0.96	0.68	/	/	/	/
72	/	/	/	/	/	/	/	/	/	/	/	/	/	/
73	/	/	/	/	/	/	/	/	/	/	/	/	/	/
74	5.54	/	/	/	/	/	/	1.36	/	/	/	/	/	/
75	5.03	9.08	/	/	/	/	/	0.51	1.16	/	/	/	/	/
76	/	/	/	/	/	/	/	/	/	/	/	/	/	/
77	5.62	/	/	/	/	/	/	1.81	/	/	/	/	/	/
78	5.54	8.15	/	/	/	/	/	0.92	2.58	/	/	/	/	/
79	/	/	/	/	/	/	/	/	/	/	/	/	/	/
80	/	/	/	/	/	/	/	/	/	/	/	/	/	/
81	/	/	/	/	/	/	/	/	/	/	/	/	/	/
82	4.00	5.31	9.07	10.67	/	/	/	0.60	0.67	0.77	0.80	/	/	/
83	5.52	8.68	11.35	/	/	/	/	0.97	1.10	1.37	/	/	/	/
84	7.56	/	/	/	/	/	/	1.36	/	/	/	/	/	/
85	5.53	/	/	/	/	/	/	1.12	/	/	/	/	/	/
86	4.66	8.54	11.55	/	/	/	/	1.20	1.27	1.55	/	/	/	/
87	9.31	/	/	/	/	/	/	1.45	/	/	/	/	/	/
88	5.75	9.33	10.16	/	/	/	/	1.21	1.48	1.49	/	/	/	/
89	/	/	/	/	/	/	/	/	/	/	/	/	/	/
90	/	/	/	/	/	/	/	/	/	/	/	/	/	/
91	5.37	6.42	8.50	/	/	/	/	0.47	0.84	0.95	/	/	/	/
92	/	/	/	/	/	/	/	/	/	/	/	/	/	/
93	/	/	/	/	/	/	/	/	/	/	/	/	/	/
94	/	/	/	/	/	/	/	/	/	/	/	/	/	/
95	5.80	/	/	/	/	/	/	2.02	/	/	/	/	/	/
96	5.31	9.15	/	/	/	/	/	1.20	1.19	/	/	/	/	/
97	5.23	9.64	/	/	/	/	/	0.88	0.73	/	/	/	/	/
98	/	/	/	/	/	/	/	/	/	/	/	/	/	/
99	5.47	8.13	9.89	/	/	/	/	0.84	0.71	1.15	/	/	/	/
100	5.99	10.48	/	/	/	/	/	1.33	1.45	/	/	/	/	/

Appendix Table B.8b Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 200 length measurements using the two partitions for grouping the European hake data.

	Sample size = 200 length measurements													
	Estimates													
	2 cm													
	mean 1 (cm)	*mean 2 (cm)*	*mean 3 (cm)*	*mean 4 (cm)*	*mean 5 (cm)*	*mean 6 (cm)*	*mean 7 (cm)*	*SD 1 (cm)*	*SD 2 (cm)*	*SD 3 (cm)*	*SD 4 (cm)*	*SD 5 (cm)*	*SD 6 (cm)*	*SD 7 (cm)*
1	19.06	33.19	38.35	48.00	/	/	/	2.55	1.47	1.06	0.60	/	/	/
2	18.87	26.45	34.04	44.03	53.00	/	/	1.67	1.93	1.11	1.75	0.85	/	/
3	19.04	26.67	41.62	49.50	58.23	/	/	1.03	1.43	1.67	0.90	0.82	/	/
4	19.16	25.49	33.49	40.93	49.69	/	/	1.11	1.13	1.67	1.57	1.23	/	/
5	20.15	26.08	34.80	42.53	52.00	56.23	/	1.96	1.34	1.64	1.30	0.85	0.82	/
6	19.30	27.84	34.04	44.50	52.00	57.00	/	1.40	1.76	1.11	1.35	1.10	0.67	/
7	18.67	27.56	37.36	46.24	51.33	57.25	/	1.10	1.53	1.32	1.06	1.45	1.80	/
8	18.50	23.50	33.01	41.07	50.67	/	/	1.32	0.95	1.04	1.11	0.85	/	/
9	19.28	25.69	33.50	42.11	50.50	/	/	1.08	1.31	1.23	0.75	1.20	/	/
10	19.56	26.27	37.50	44.50	57.78	/	/	1.03	1.51	1.23	1.15	2.22	/	/
11	18.85	25.72	33.73	42.73	49.50	/	/	0.97	1.14	1.20	1.00	1.06	/	/
12	18.91	26.71	40.56	/	/	/	/	1.42	1.06	1.70	/	/	/	/
13	18.83	28.89	33.21	41.50	49.00	/	/	1.10	1.29	1.11	1.35	0.67	/	/
14	19.98	26.50	36.51	45.04	59.73	/	/	0.90	1.38	1.36	1.15	1.29	/	/
15	19.09	25.23	35.68	43.17	58.00	/	/	1.11	1.02	1.64	0.98	0.85	/	/
16	19.14	25.12	32.67	42.14	54.11	/	/	1.17	1.08	1.87	0.63	1.15	/	/
17	27.02	31.81	34.85	42.50	51.02	/	/	1.61	3.34	1.61	0.83	1.00	/	/
18	18.66	27.50	35.07	43.25	/	/	/	1.16	1.13	1.57	3.33	/	/	/
19	19.18	26.95	35.24	41.83	51.50	/	/	1.36	1.55	1.35	1.49	1.06	/	/
20	19.77	30.92	34.00	41.24	49.30	/	/	0.92	1.12	0.74	1.06	0.93	/	/
21	18.75	27.43	38.76	44.37	53.00	/	/	0.88	2.26	1.06	1.81	0.85	/	/
22	18.87	27.05	34.70	41.50	51.20	60.11	/	0.89	1.71	0.93	0.86	1.28	1.24	/
23	19.45	26.01	35.04	42.89	/	/	/	1.66	0.92	1.15	1.70	/	/	/
24	18.73	25.50	33.31	41.55	49.50	/	/	1.07	0.78	1.20	1.26	1.06	/	/
25	18.80	26.92	31.31	41.15	55.50	/	/	1.15	1.43	3.33	1.23	0.95	/	/
26	18.39	26.13	42.50	62.92	/	/	/	1.11	1.67	1.00	1.35	/	/	/
27	19.14	25.75	34.10	41.50	55.02	/	/	1.86	0.90	0.93	1.11	1.91	/	/
28	18.96	29.40	39.09	42.26	50.11	/	/	1.18	3.54	1.43	1.01	1.62	/	/
29	18.85	26.75	35.28	41.20	48.37	/	/	1.22	1.05	2.07	1.48	1.53	/	/
30	19.24	28.59	33.50	40.27	52.93	/	/	1.27	1.24	1.86	1.51	1.20	/	/
31	18.76	27.45	33.09	49.17	/	/	/	1.54	1.73	1.33	0.98	/	/	/
32	19.28	26.29	31.45	45.14	48.14	/	/	1.04	0.96	1.23	0.63	0.84	/	/
33	18.77	26.03	43.58	46.75	/	/	/	1.29	1.20	2.69	1.43	/	/	/
34	18.75	25.63	35.74	44.78	50.00	58.23	/	1.61	1.56	1.04	1.00	0.67	0.82	/
35	18.70	30.50	54.81	/	/	/	/	1.29	1.70	1.39	/	/	/	/
36	19.30	27.68	34.44	41.67	48.50	/	/	1.40	1.42	1.86	0.86	1.06	/	/
37	18.68	27.46	32.81	40.79	48.50	63.50	/	1.33	1.89	1.16	1.11	1.57	1.20	/
38	18.40	27.25	33.61	43.68	51.00	/	/	0.97	1.44	1.22	1.37	0.85	/	/
39	19.32	27.18	41.73	47.50	51.50	62.00	/	1.24	1.58	1.02	1.70	1.20	0.85	/
40	19.22	27.07	43.17	48.22	55.00	/	/	1.12	1.02	0.69	2.21	0.85	/	/
41	18.79	31.25	34.00	43.10	51.75	/	/	1.30	1.49	1.48	1.29	1.82	/	/
42	19.14	38.17	43.10	54.24	/	/	/	1.29	0.69	1.96	1.06	/	/	/
43	19.02	26.63	35.72	43.17	57.00	/	/	0.99	1.32	1.29	0.69	0.85	/	/
44	18.59	26.72	32.36	40.17	51.23	/	/	1.39	1.09	1.66	0.98	0.82	/	/
45	19.23	26.45	35.35	40.67	52.17	/	/	1.08	1.51	1.06	0.85	1.20	/	/
46	18.85	28.06	36.50	41.89	51.50	58.00	/	1.36	0.71	2.22	1.32	1.06	0.56	/
47	18.70	26.06	33.50	41.84	55.50	59.00	/	1.48	1.06	0.91	1.09	1.70	0.85	/
48	18.39	27.30	33.82	45.00	53.50	59.50	/	1.28	1.89	1.13	1.90	1.06	1.06	/
49	18.21	27.88	33.33	39.06	/	/	/	1.19	2.59	1.11	0.90	/	/	/
50	18.91	27.38	32.91	43.50	50.04	/	/	1.80	1.60	1.39	0.93	1.15	/	/
51	18.84	25.50	32.13	41.50	/	/	/	1.12	1.47	2.22	0.77	/	/	/
52	18.50	26.38	34.89	40.75	49.50	/	/	1.23	1.05	1.29	1.43	1.35	/	/
53	19.03	27.55	33.89	39.79	48.72	/	/	1.13	1.79	1.56	1.57	1.28	/	/
54	19.55	27.30	33.30	46.17	51.14	/	/	1.33	1.32	1.10	0.69	0.63	/	/
55	19.37	26.37	43.26	/	/	/	/	1.11	1.27	1.85	/	/	/	/
56	18.60	26.58	38.96	50.50	/	/	/	1.80	1.13	1.11	0.90	/	/	/
57	18.24	24.71	34.09	42.28	49.24	58.00	/	1.54	1.38	1.43	1.29	1.06	0.85	/
58	18.53	31.35	40.93	52.55	/	/	/	1.87	1.26	0.96	1.37	/	/	/
59	19.10	25.63	32.74	40.11	50.00	57.00	/	1.32	1.30	1.18	1.70	0.85	0.67	/
60	18.76	26.30	33.17	42.94	50.40	58.50	/	1.13	1.76	0.95	1.10	1.73	0.98	/
61	23.38	27.36	34.04	47.76	/	/	/	0.74	1.02	1.00	1.06	/	/	/
62	18.38	26.67	31.76	47.50	50.50	/	/	1.12	1.58	1.62	1.35	1.35	/	/
63	26.90	31.73	41.66	49.37	57.73	/	/	1.28	1.54	1.35	1.53	1.29	/	/
64	19.21	26.31	35.68	43.50	/	/	/	1.26	1.15	1.14	1.20	/	/	/
65	19.43	25.38	33.94	48.20	49.10	/	/	1.08	1.25	2.03	1.23	2.07	/	/
66	18.60	23.50	31.79	38.30	/	/	/	1.74	1.35	0.94	0.93	/	/	/
67	18.58	26.84	34.50	42.00	50.75	/	/	1.61	2.29	1.16	0.67	1.70	/	/
68	19.75	27.41	33.66	50.35	/	/	/	1.12	1.02	1.68	1.70	/	/	/
69	18.30	26.82	35.29	41.30	51.50	57.12	/	1.57	1.71	1.74	0.93	0.90	1.65	/
70	18.50	26.11	36.24	46.50	62.50	/	/	1.04	0.94	1.06	1.06	0.98	/	/
71	19.08	25.84	32.91	41.64	58.12	/	/	1.21	1.10	1.92	1.19	1.65	/	/
72	19.12	27.36	43.50	46.84	51.25	56.27	/	1.37	1.64	0.90	1.09	1.43	1.00	/
73	18.95	25.67	33.41	46.04	57.00	/	/	1.40	1.00	0.81	1.15	0.85	/	/
74	18.70	27.00	34.33	48.50	52.92	/	/	1.72	1.95	1.11	1.06	1.35	/	/
75	18.70	27.33	35.09	45.00	/	/	/	1.54	1.31	1.06	1.48	/	/	/
76	19.25	26.34	31.52	47.23	54.00	/	/	1.31	1.65	2.66	1.66	0.85	/	/
77	19.43	27.96	32.37	46.33	48.84	/	/	1.39	1.08	1.15	2.02	1.09	/	/
78	18.58	27.32	37.12	43.50	51.83	/	/	1.56	1.49	1.13	1.23	1.20	/	/
79	19.50	26.50	43.96	50.93	59.50	/	/	1.36	1.73	1.15	1.20	1.20	/	/
80	19.42	26.34	32.14	44.65	48.50	/	/	1.52	1.25	0.82	0.82	0.90	/	/
81	19.38	26.33	38.98	46.76	49.50	/	/	1.02	1.28	1.06	1.06	1.57	/	/
82	19.36	24.33	40.00	48.50	58.27	/	/	1.43	0.85	1.48	0.86	1.51	/	/
83	18.41	25.92	33.13	44.11	50.00	59.00	/	0.98	0.80	0.90	0.56	0.67	0.85	/
84	19.02	25.17	32.74	38.67	57.50	60.00	/	1.12	1.19	0.83	1.58	1.06	0.85	/
85	18.55	26.86	33.50	40.50	51.50	/	/	1.31	1.50	1.05	1.11	1.20	/	/
86	18.92	24.90	34.95	41.50	52.11	62.00	/	1.36	1.54	1.28	0.85	1.24	0.85	/
87	19.03	26.69	33.80	53.41	/	/	/	1.67	1.19	1.23	1.22	/	/	/
88	19.74	26.96	35.67	45.23	/	/	/	0.97	1.14	2.11	0.82	/	/	/
89	19.16	26.92	39.50	48.72	51.97	/	/	1.38	2.55	1.11	0.98	1.20	/	/
90	19.48	26.94	36.50	/	/	/	/	1.39	1.31	0.93	/	/	/	/
91	18.99	25.50	41.89	52.08	56.14	/	/	1.21	1.28	1.70	1.35	0.63	/	/
92	19.36	27.17	35.19	42.00	53.82	/	/	1.61	1.28	1.01	1.48	1.29	/	/
93	19.77	26.91	33.97	47.12	50.44	/	/	1.13	1.24	0.95	1.13	1.70	/	/
94	18.73	25.98	38.17	42.05	49.00	/	/	1.09	1.38	0.98	1.29	0.85	/	/
95	18.94	26.50	34.30	42.50	/	/	/	1.28	1.25	1.09	1.15	/	/	/
96	18.35	26.61	36.04	45.68	49.50	/	/	1.11	1.80	1.15	1.01	0.98	/	/
97	18.81	25.61	36.76	39.00	47.11	/	/	1.85	2.12	1.06	0.63	1.03	/	/
98	19.29	27.22	38.75	42.35	/	/	/	1.06	1.69	1.18	2.07	/	/	/
99	18.13	26.52	40.11	43.35	50.05	/	/	2.33	1.42	1.32	1.77	1.49	/	/
100	19.32	33.38	36.51	/	/	/	/	1.57	1.26	1.29	/	/	/	/

Appendix Table B.8c Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 200 length measurements using the two partitions for grouping the European hake data.

	Sample size = 200 length measurements													
	% Bias													
	Birgè and Rozenholc algorithm													
	mean 1	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*mean 7*	*SD 1*	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*	*SD 7*
1	/	/	/	/	/	/	/	/	/	/	/	/	/	/
2	/	/	/	/	/	/	/	/	/	/	/	/	/	/
3	/	/	/	/	/	/	/	/	/	/	/	/	/	/
4	/	/	/	/	/	/	/	/	/	/	/	/	/	/
5	6.63	5.90	9.02	/	/	/	/	17.15	53.10	20.56	/	/	/	/
6	7.65	15.25	/	/	/	/	/	57.05	27.47	/	/	/	/	/
7	/	/	/	/	/	/	/	/	/	/	/	/	/	/
8	9.14	9.63	9.52	/	/	/	/	36.61	26.86	23.46	/	/	/	/
9	0.11	/	/	/	/	/	/	172.32	/	/	/	/	/	/
10	/	/	/	/	/	/	/	/	/	/	/	/	/	/
11	9.07	6.96	11.99	/	/	/	/	62.73	197.08	26.64	/	/	/	/
12	/	/	/	/	/	/	/	/	/	/	/	/	/	/
13	9.15	/	/	/	/	/	/	140.41	/	/	/	/	/	/
14	/	/	/	/	/	/	/	/	/	/	/	/	/	/
15	1.57	/	/	/	/	/	/	154.61	/	/	/	/	/	/
16	9.16	17.11	17.53	/	/	/	/	62.04	12.38	3.25	/	/	/	/
17	11.53	17.02	/	/	/	/	/	78.06	45.27	/	/	/	/	/
18	7.36	5.53	11.85	/	/	/	/	44.07	52.01	20.26	/	/	/	/
19	/	/	/	/	/	/	/	/	/	/	/	/	/	/
20	/	/	/	/	/	/	/	/	/	/	/	/	/	/
21	/	/	/	/	/	/	/	/	/	/	/	/	/	/
22	/	/	/	/	/	/	/	/	/	/	/	/	/	/
23	/	/	/	/	/	/	/	/	/	/	/	/	/	/
24	4.71	3.80	6.76	9.43	/	/	/	41.71	26.56	23.76	4.60	/	/	/
25	/	/	/	/	/	/	/	/	/	/	/	/	/	/
26	8.19	10.20	/	/	/	/	/	65.67	65.62	/	/	/	/	/
27	5.53	4.41	/	/	/	/	/	10.04	28.20	/	/	/	/	/
28	7.81	8.01	13.91	/	/	/	/	165.69	69.15	34.74	/	/	/	/
29	11.30	14.74	/	/	/	/	/	79.63	50.15	/	/	/	/	/
30	/	/	/	/	/	/	/	/	/	/	/	/	/	/
31	/	/	/	/	/	/	/	/	/	/	/	/	/	/
32	0.62	2.39	3.59	3.81	/	/	/	15.18	15.83	9.43	14.89	/	/	/
33	6.50	15.34	/	/	/	/	/	60.78	44.05	/	/	/	/	/
34	9.29	11.15	/	/	/	/	/	88.38	110.42	/	/	/	/	/
35	/	/	/	/	/	/	/	/	/	/	/	/	/	/
36	0.19	1.44	3.49	3.39	5.28	/	/	15.98	34.56	41.80	11.59	2.22	/	/
37	/	/	/	/	/	/	/	/	/	/	/	/	/	/
38	9.60	15.57	/	/	/	/	/	58.35	68.92	/	/	/	/	/
39	9.58	13.82	/	/	/	/	/	104.51	72.08	/	/	/	/	/
40	7.73	12.44	/	/	/	/	/	83.28	48.57	/	/	/	/	/
41	/	/	/	/	/	/	/	/	/	/	/	/	/	/
42	5.43	19.35	/	/	/	/	/	91.70	48.09	/	/	/	/	/
43	9.37	14.29	/	/	/	/	/	45.28	33.14	/	/	/	/	/
44	9.11	16.07	/	/	/	/	/	80.66	58.24	/	/	/	/	/
45	/	/	/	/	/	/	/	/	/	/	/	/	/	/
46	/	/	/	/	/	/	/	/	/	/	/	/	/	/
47	/	/	/	/	/	/	/	/	/	/	/	/	/	/
48	9.24	/	/	/	/	/	/	65.86	/	/	/	/	/	/
49	7.91	7.59	8.28	/	/	/	/	40.59	32.18	19.37	/	/	/	/
50	/	/	/	/	/	/	/	/	/	/	/	/	/	/
51	7.93	14.11	15.18	/	/	/	/	31.54	10.08	14.93	/	/	/	/
52	/	/	/	/	/	/	/	/	/	/	/	/	/	/
53	9.38	12.36	/	/	/	/	/	93.84	48.22	/	/	/	/	/
54	/	/	/	/	/	/	/	/	/	/	/	/	/	/
55	8.17	6.92	13.07	/	/	/	/	49.40	57.71	32.70	/	/	/	/
56	8.76	14.23	/	/	/	/	/	54.49	48.17	/	/	/	/	/
57	/	/	/	/	/	/	/	/	/	/	/	/	/	/
58	6.92	8.40	/	/	/	/	/	66.53	54.27	/	/	/	/	/
59	6.73	4.47	3.51	8.45	/	/	/	29.56	32.49	12.64	9.19	/	/	/
60	/	/	/	/	/	/	/	/	/	/	/	/	/	/
61	0.24	0.32	7.52	9.10	/	/	/	12.78	11.53	17.48	3.24	/	/	/
62	7.72	13.30	/	/	/	/	/	129.40	60.92	/	/	/	/	/
63	9.35	12.50	/	/	/	/	/	75.41	76.22	/	/	/	/	/
64	0.00	0.00	/	/	/	/	/	/	/	/	/	/	/	/
65	8.53	2.19	9.41	/	/	/	/	52.40	50.26	19.53	/	/	/	/
66	8.93	18.33	/	/	/	/	/	56.64	22.60	/	/	/	/	/
67	/	/	/	/	/	/	/	/	/	/	/	/	/	/
68	/	/	/	/	/	/	/	/	/	/	/	/	/	/
69	/	/	/	/	/	/	/	/	/	/	/	/	/	/
70	8.77	21.41	/	/	/	/	/	42.64	35.44	/	/	/	/	/
71	8.12	10.39	14.32	/	/	/	/	44.50	29.47	9.16	/	/	/	/
72	/	/	/	/	/	/	/	/	/	/	/	/	/	/
73	/	/	/	/	/	/	/	/	/	/	/	/	/	/
74	8.58	/	/	/	/	/	/	74.22	/	/	/	/	/	/
75	5.93	13.53	/	/	/	/	/	15.71	39.80	/	/	/	/	/
76	/	/	/	/	/	/	/	/	/	/	/	/	/	/
77	8.98	/	/	/	/	/	/	105.40	/	/	/	/	/	/
78	8.56	10.10	/	/	/	/	/	43.74	112.94	/	/	/	/	/
79	/	/	/	/	/	/	/	/	/	/	/	/	/	/
80	/	/	/	/	/	/	/	/	/	/	/	/	/	/
81	/	/	/	/	/	/	/	/	/	/	/	/	/	/
82	0.61	-0.39	7.57	6.75	/	/	/	21.95	14.56	13.11	8.71	/	/	/
83	8.48	12.06	14.49	/	/	/	/	47.57	36.86	38.91	/	/	/	/
84	18.97	/	/	/	/	/	/	74.67	/	/	/	/	/	/
85	8.51	/	/	/	/	/	/	57.61	/	/	/	/	/	/
86	4.01	11.52	15.10	/	/	/	/	63.26	45.47	46.62	/	/	/	/
87	28.03	/	/	/	/	/	/	80.97	/	/	/	/	/	/
88	9.65	14.47	10.87	/	/	/	/	64.11	56.21	44.13	/	/	/	/
89	/	/	/	/	/	/	/	/	/	/	/	/	/	/
90	/	/	/	/	/	/	/	/	/	/	/	/	/	/
91	7.67	3.69	5.84	/	/	/	/	12.85	23.25	21.12	/	/	/	/
92	/	/	/	/	/	/	/	/	/	/	/	/	/	/
93	/	/	/	/	/	/	/	/	/	/	/	/	/	/
94	/	/	/	/	/	/	/	/	/	/	/	/	/	/
95	9.93	/	/	/	/	/	/	120.47	/	/	/	/	/	/
96	7.40	13.80	/	/	/	/	/	63.14	41.32	/	/	/	/	/
97	6.96	15.60	/	/	/	/	/	40.83	17.88	/	/	/	/	/
98	/	/	/	/	/	/	/	/	/	/	/	/	/	/
99	8.19	10.02	10.06	/	/	/	/	38.06	16.78	29.64	/	/	/	/
100	10.88	18.68	/	/	/	/	/	72.10	54.59	/	/	/	/	/

Appendix Table B.8d Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 200 length measurements using the two partitions for grouping the European hake data.

Sample size = 200 length measurements														
% Bias														
2 cm														
	mean 1	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*mean 7*	*SD 1*	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*	*SD 7*
1	-1.70	22.57	16.56	20.36	/	/	/	76.99	-24.46	-54.10	-78.40	/	/	/
2	-2.66	-2.32	3.48	10.41	12.43	/	/	16.00	-0.71	-51.95	-37.17	-73.87	/	/
3	-1.78	-1.53	26.52	24.12	23.53	/	/	-28.78	-26.21	-27.92	-67.73	-74.91	/	/
4	-1.17	-5.86	1.80	2.63	5.41	/	/	-22.59	-41.71	-27.97	-43.51	-62.21	/	/
5	3.94	-3.71	5.78	6.65	10.31	4.77	/	35.89	-30.71	-29.10	-53.39	-73.87	-77.84	/
6	-0.46	2.81	3.48	11.58	10.31	6.20	/	-2.57	-9.40	-51.95	-51.47	-66.19	-81.67	/
7	-3.72	1.77	13.56	15.95	8.89	6.67	/	-23.80	-20.91	-42.96	-62.00	-55.45	-51.04	/
8	-4.59	-13.22	0.32	2.99	7.48	/	/	-8.00	-50.82	-55.26	-59.90	-73.87	/	/
9	-0.56	-5.13	1.82	5.60	7.13	/	/	-24.78	-32.41	-46.98	-73.13	-63.04	/	/
10	0.88	-2.97	13.98	11.58	22.57	/	/	-28.22	-22.09	-46.98	-58.52	-31.66	/	/
11	-2.78	-5.02	2.51	7.14	5.01	/	/	-32.44	-41.27	-48.23	-64.16	-67.49	/	/
12	-2.46	-1.37	23.27	/	/	/	/	-1.46	-45.26	-26.78	/	/	/	/
13	-2.90	6.69	0.95	4.06	3.95	/	/	-23.74	-33.56	-51.95	-51.47	-79.24	/	/
14	3.03	-2.14	10.96	12.94	26.71	/	/	-37.70	-29.12	-41.21	-58.52	-60.19	/	/
15	-1.57	-6.85	8.44	8.24	23.04	/	/	-23.02	-47.25	-29.23	-64.72	-73.87	/	/
16	-1.28	-7.23	-0.68	5.66	14.80	/	/	-18.86	-44.46	-19.57	-77.37	-64.52	/	/
17	39.34	17.45	5.92	6.57	8.23	/	/	11.61	72.06	-30.56	-70.08	-69.09	/	/
18	-3.79	1.55	6.60	8.46	/	/	/	-19.22	-41.84	-32.31	19.66	/	/	/
19	-1.07	-0.49	7.11	4.88	9.25	/	/	-5.89	-20.23	-41.84	-46.39	-67.49	/	/
20	1.96	14.19	3.34	3.42	4.58	/	/	-35.80	-42.17	-68.16	-62.00	-71.32	/	/
21	-3.28	1.29	17.81	11.25	12.43	/	/	-38.79	16.29	-54.46	-34.92	-73.87	/	/
22	-2.69	-0.12	5.47	4.06	8.62	12.01	/	-38.49	-11.79	-59.83	-69.09	-60.65	-66.27	/
23	0.30	-3.96	6.50	7.55	/	/	/	15.46	-52.46	-50.30	-38.90	/	/	/
24	-3.39	-5.83	1.23	4.19	5.01	/	/	-25.49	-59.61	-48.23	-54.65	-67.49	/	/
25	-3.04	-0.58	-4.84	3.19	17.73	/	/	-20.26	-26.39	43.66	-55.75	-70.64	/	/
26	-5.15	-3.52	29.18	57.77	/	/	/	-23.04	-13.72	-57.06	-51.47	/	/	/
27	-1.28	-4.92	3.64	4.06	16.72	/	/	28.87	-53.52	-59.83	-59.90	-41.29	/	/
28	-2.24	8.58	18.80	5.97	6.30	/	/	-18.23	82.23	-38.45	-63.53	-50.18	/	/
29	-2.77	-1.21	7.23	3.32	2.61	/	/	-15.15	-46.08	-10.63	-46.86	-52.92	/	/
30	-0.79	5.59	1.82	0.99	12.28	/	/	-12.08	-36.05	-19.64	-45.63	-63.11	/	/
31	-3.27	1.38	0.59	23.29	/	/	/	6.61	-10.75	-42.78	-64.72	/	/	/
32	-0.57	-2.93	-4.40	13.18	2.13	/	/	-27.50	-50.39	-46.98	-77.37	-74.24	/	/
33	-3.21	-3.88	32.45	17.23	/	/	/	-10.46	-38.09	15.77	-48.63	/	/	/
34	-3.31	-5.34	8.64	12.28	6.07	8.50	/	11.61	-19.41	-54.97	-64.00	-79.24	-77.84	/
35	-3.55	12.63	66.60	/	/	/	/	-10.62	-12.44	-39.88	/	/	/	/
36	-0.45	2.23	4.67	4.49	2.89	/	/	-2.47	-26.86	-20.04	-69.09	-67.49	/	/
37	-3.67	1.41	-0.26	2.27	2.89	18.32	/	-7.42	-2.57	-49.82	-59.90	-51.68	-67.36	/
38	-5.11	0.63	2.15	9.53	8.19	/	/	-32.80	-25.90	-47.45	-50.74	-73.87	/	/
39	-0.38	0.37	26.83	19.11	9.25	15.52	/	-13.69	-18.30	-56.09	-38.90	-63.04	-76.92	/
40	-0.88	-0.04	31.21	20.92	16.67	/	/	-22.49	-47.25	-70.11	-20.39	-73.87	/	/
41	-3.10	15.40	3.33	8.07	9.78	/	/	-9.65	-22.99	-36.32	-53.45	-43.88	/	/
42	-1.28	40.94	31.00	36.01	/	/	/	-10.36	-64.25	-15.45	-62.00	/	/	/
43	-1.90	-1.66	8.59	8.24	20.92	/	/	-31.24	-31.95	-44.45	-75.06	-73.87	/	/
44	-4.11	-1.32	-1.64	0.72	8.68	/	/	-3.50	-43.73	-28.49	-64.72	-74.91	/	/
45	-0.83	-2.31	7.44	1.97	10.66	/	/	-24.78	-22.20	-54.46	-69.45	-63.04	/	/
46	-2.77	3.61	10.94	5.04	9.25	8.07	/	-5.75	-63.31	-4.27	-52.34	-67.49	-84.85	/
47	-3.58	-3.77	1.82	4.92	17.73	9.93	/	3.07	-45.54	-60.82	-60.68	-47.73	-76.92	/
48	-5.17	0.81	2.78	12.84	13.49	10.86	/	-11.04	-2.71	-51.33	-31.69	-67.49	-71.29	/
49	-6.09	2.95	1.31	-2.06	/	/	/	-17.40	33.70	-51.95	-67.73	/	/	/
50	-2.47	1.12	0.02	9.08	6.15	/	/	24.87	-17.57	-39.93	-66.48	-64.52	/	/
51	-2.86	-5.83	-2.33	4.06	/	/	/	-21.91	-24.17	-4.27	-72.42	/	/	/
52	-4.59	-2.60	6.05	2.19	5.01	/	/	-14.60	-45.67	-44.45	-48.63	-58.48	/	/
53	-1.86	1.75	2.99	-0.22	3.35	/	/	-21.32	-7.69	-32.90	-43.51	-60.57	/	/
54	0.85	0.83	1.23	15.76	8.48	/	/	-7.82	-31.88	-52.64	-75.06	-80.64	/	/
55	-0.11	-2.60	31.50	/	/	/	/	-22.88	-34.33	-20.21	/	/	/	/
56	-4.06	-1.85	18.40	26.63	/	/	/	24.66	-41.67	-51.95	-67.73	/	/	/
57	-5.92	-8.76	3.61	6.01	4.46	8.07	/	6.94	-28.96	-38.45	-53.64	-67.49	-76.92	/
58	-4.45	15.76	24.40	31.76	/	/	/	30.14	-34.87	-58.61	-50.89	/	/	/
59	-1.51	-5.37	-0.49	0.58	6.07	6.20	/	-8.33	-32.85	-49.12	-38.90	-73.87	-81.67	/
60	-3.26	-2.88	0.83	7.68	6.91	9.00	/	-21.63	-9.36	-59.21	-60.50	-46.91	-73.35	/
61	20.57	1.03	3.47	19.75	/	/	/	-48.70	-47.50	-57.06	-62.00	/	/	/
62	-5.21	-1.52	-3.47	19.11	7.13	/	/	-21.97	-18.71	-30.18	-51.47	-58.48	/	/
63	38.75	17.16	26.62	23.80	22.47	/	/	-11.04	-20.81	-41.84	-44.96	-60.19	/	/
64	-0.93	-2.85	8.44	9.08	/	/	/	-12.56	-40.57	-50.89	-56.79	/	/	/
65	0.21	-6.26	3.15	20.86	4.17	/	/	-25.27	-35.59	-12.41	-55.75	-36.25	/	/
66	-4.08	-13.22	-3.36	-3.96	/	/	/	20.92	-30.45	-59.65	-66.48	/	/	/
67	-4.18	-0.90	4.86	5.32	7.66	/	/	11.90	18.21	-50.09	-75.73	-47.57	/	/
68	1.87	1.22	2.32	26.26	/	/	/	-22.48	-47.46	-27.80	-39.00	/	/	/
69	-5.62	-0.95	7.27	3.56	9.25	6.43	/	9.33	-11.89	-25.09	-66.48	-72.40	-55.10	/
70	-4.59	-3.59	10.16	16.60	32.58	/	/	-27.97	-51.69	-54.46	-62.00	-69.82	/	/
71	-1.57	-4.57	0.02	4.43	23.30	/	/	-16.10	-43.35	-17.16	-57.08	-49.15	/	/
72	-1.37	1.04	32.22	17.46	8.72	4.85	/	-4.68	-15.32	-61.33	-60.68	-56.00	-72.93	/
73	-2.27	-5.20	1.56	15.44	20.92	/	/	-2.80	-48.36	-65.04	-58.52	-73.87	/	/
74	-3.55	-0.30	4.35	21.61	12.26	/	/	19.38	0.50	-51.95	-62.00	-58.48	/	/
75	-3.54	0.92	6.66	12.83	/	/	/	6.67	-32.33	-54.46	-46.86	/	/	/
76	-0.70	-2.73	-4.18	18.43	14.55	/	/	-8.75	-15.00	14.85	-40.13	-73.87	/	/
77	0.20	3.27	-1.60	16.17	3.61	/	/	-3.21	-44.53	-50.30	-27.36	-66.37	/	/
78	-4.17	0.87	12.83	9.08	9.96	/	/	8.27	-23.28	-51.10	-55.75	-63.04	/	/
79	0.57	-2.14	33.62	27.70	26.22	/	/	-5.77	-10.61	-50.30	-56.87	-63.04	/	/
80	0.14	-2.72	-2.31	11.97	2.89	/	/	5.54	-35.47	-64.72	-70.61	-72.40	/	/
81	-0.03	-2.76	18.49	17.25	5.01	/	/	-29.22	-34.23	-54.46	-62.00	-51.68	/	/
82	-0.13	-10.14	21.57	21.61	23.62	/	/	-0.71	-56.22	-36.32	-69.09	-53.49	/	/
83	-5.07	-4.29	0.69	10.60	6.07	9.93	/	-31.89	-58.62	-61.33	-79.89	-79.24	-76.92	/
84	-1.90	-7.07	-0.49	-3.05	21.98	11.79	/	-22.35	-38.82	-64.14	-43.07	-67.49	-76.92	/
85	-4.31	-0.82	1.82	1.55	9.25	/	/	-9.34	-22.46	-54.79	-59.90	-63.04	/	/
86	-2.40	-8.04	6.22	4.06	10.55	15.52	/	-5.42	-20.81	-44.84	-69.45	-61.80	-76.92	/
87	-1.87	-1.43	2.74	33.94	/	/	/	15.80	-38.58	-46.98	-56.11	/	/	/
88	1.82	-0.46	8.42	13.42	/	/	/	-32.44	-41.17	-9.20	-70.67	/	/	/
89	-1.19	-0.61	20.06	22.17	10.25	/	/	-4.12	31.40	-51.95	-64.72	-63.04	/	/
90	0.45	-0.52	10.94	/	/	/	/	-3.41	-32.48	-59.83	/	/	/	/
91	-2.04	-5.83	27.33	30.59	19.09	/	/	-15.70	-33.90	-26.78	-51.47	-80.64	/	/
92	-0.15	0.32	6.95	5.31	14.17	/	/	11.69	-33.90	-56.26	-46.86	-60.19	/	/
93	1.97	-0.62	3.24	18.16	7.01	/	/	-21.44	-36.30	-59.21	-59.19	-47.73	/	/
94	-3.43	-4.06	16.01	5.43	3.95	/	/	-24.32	-28.82	-57.73	-53.64	-73.87	/	/
95	-2.30	-2.14	4.25	6.57	/	/	/	-10.99	-35.59	-53.14	-58.52	/	/	/
96	-5.34	-1.74	9.54	14.56	5.01	/	/	-23.26	-7.21	-50.30	-63.79	-69.82	/	/
97	-3.00	-5.44	11.73	-2.21	-0.06	/	/	28.29	9.44	-54.46	-77.27	-68.41	/	/
98	-0.52	0.50	17.79	6.20	/	/	/	-26.26	-12.86	-49.12	-25.56	/	/	/
99	-6.48	-2.08	21.91	8.69	6.17	/	/	61.65	-26.57	-42.89	-36.22	-54.03	/	/
100	-0.38	23.27	10.97	/	/	/	/	9.06	-34.87	-44.45	/	/	/	/

Appendix Table B.9a Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 500 length measurements using the two partitions for grouping the European hake data.

Sample size = 500 length measurements														
Estimates														
Birgè and Rozenholc algorithm														
	mean 1 (cm)	*mean 2 (cm)*	*mean 3 (cm)*	*mean 4 (cm)*	*mean 5 (cm)*	*mean 6 (cm)*	*mean 7 (cm)*	*SD 1 (cm)*	*SD 2 (cm)*	*SD 3 (cm)*	*SD 4 (cm)*	*SD 5 (cm)*	*SD 6 (cm)*	*SD 7 (cm)*
1	13.71	26.65	35.42	/	/	/	/	-0.16	0.51	0.42	/	/	/	/
2	14.10	21.42	36.72	/	/	/	/	1.14	0.61	1.53	/	/	/	/
3	23.23	47.10	/	/	/	/	/	2.01	2.40	/	/	/	/	/
4	20.84	47.50	46.02	/	/	/	/	1.94	4.07	3.28	/	/	/	/
5	21.46	37.38	44.46	/	/	/	/	1.90	2.05	1.15	/	/	/	/
6	21.49	35.39	47.20	/	/	/	/	1.16	2.41	1.84	/	/	/	/
7	22.18	34.10	33.61	/	/	/	/	4.91	7.11	6.65	/	/	/	/
8	21.73	27.89	43.15	/	/	/	/	1.03	2.29	1.45	/	/	/	/
9	13.85	20.63	34.62	50.91	/	/	/	0.20	0.97	2.75	2.52	/	/	/
10	22.25	44.44	/	/	/	/	/	4.54	3.21	/	/	/	/	/
11	13.67	35.24	36.14	45.22	/	/	/	-0.01	-0.65	0.15	1.99	/	/	/
12	13.96	26.34	28.46	43.77	/	/	/	-0.10	6.19	1.44	1.11	/	/	/
13	13.78	22.14	24.22	35.35	48.62	/	/	0.47	1.04	2.67	4.36	3.84	/	/
14	23.07	27.82	41.04	/	/	/	/	2.86	6.37	4.25	/	/	/	/
15	47.41	/	/	/	/	/	/	5.11	/	/	/	/	/	/
16	13.34	20.76	32.49	43.81	/	/	/	-0.06	-0.12	3.95	2.22	/	/	/
17	13.75	21.73	30.45	40.90	54.88	/	/	0.05	1.38	2.60	4.39	4.23	/	/
18	43.33	/	/	/	/	/	/	7.91	/	/	/	/	/	/
19	21.46	31.71	36.04	45.65	/	/	/	1.63	3.53	1.82	3.37	/	/	/
20	14.38	23.66	24.60	35.10	50.39	/	/	0.34	2.36	3.56	4.02	3.74	/	/
21	21.81	24.65	30.39	46.47	/	/	/	2.67	2.14	6.42	4.54	/	/	/
22	23.46	32.36	/	/	/	/	/	2.97	7.23	/	/	/	/	/
23	20.82	23.75	35.71	47.37	/	/	/	2.63	8.23	3.24	3.02	/	/	/
24	21.62	31.92	35.63	-10.65	/	/	/	2.17	1.39	3.01	/	/	/	/
25	14.15	21.20	25.06	38.74	45.04	/	/	1.00	0.31	4.21	2.36	3.18	/	/
26	24.12	39.11	39.30	/	/	/	/	7.57	7.38	7.60	/	/	/	/
27	21.15	33.92	36.44	46.17	/	/	/	1.78	2.21	4.87	4.53	/	/	/
28	14.03	21.82	33.59	42.41	50.92	/	/	0.11	0.80	0.87	2.08	2.81	/	/
29	13.93	20.67	28.15	37.41	47.67	/	/	0.04	-0.37	1.52	2.74	3.07	/	/
30	14.34	22.42	/	/	/	/	/	16.50	18.39	/	/	/	/	/
31	14.05	20.94	27.48	38.92	52.75	/	/	0.21	-0.02	9.86	2.55	2.62	/	/
32	13.83	20.70	27.61	41.17	53.62	/	/	0.47	0.36	4.23	1.82	2.59	/	/
33	21.55	33.83	30.23	48.45	/	/	/	4.46	4.07	3.27	2.97	/	/	/
34	13.80	20.98	20.48	39.33	49.51	/	/	0.00	-0.13	1.60	1.78	1.98	/	/
35	23.50	42.34	/	/	/	/	/	3.13	5.66	/	/	/	/	/
36	13.76	20.44	19.28	29.45	53.84	/	/	0.19	0.17	2.96	2.84	3.93	/	/
37	23.55	27.60	/	/	/	/	/	5.14	13.49	/	/	/	/	/
38	13.93	34.20	35.15	51.01	/	/	/	-0.22	1.52	0.86	3.35	/	/	/
39	13.89	21.19	26.36	35.03	44.20	55.26	/	0.21	0.35	1.31	3.12	3.42	4.53	/
40	23.81	54.22	/	/	/	/	/	2.29	2.74	/	/	/	/	/
41	22.08	29.87	42.98	/	/	/	/	1.77	2.39	3.31	/	/	/	/
42	23.38	43.00	/	/	/	/	/	1.31	6.57	/	/	/	/	/
43	24.08	50.51	/	/	/	/	/	2.36	2.36	/	/	/	/	/
44	21.40	33.02	33.99	48.60	/	/	/	4.63	0.82	2.54	3.93	/	/	/
45	22.59	36.38	34.62	52.90	/	/	/	3.39	5.66	5.32	2.72	/	/	/
46	13.36	21.65	37.26	/	/	/	/	0.05	0.79	2.54	/	/	/	/
47	13.82	21.71	26.23	34.69	/	/	/	0.24	0.22	1.84	3.38	/	/	/
48	13.96	27.74	26.80	49.34	/	/	/	-0.15	0.19	1.21	1.39	/	/	/
49	22.79	38.98	/	/	/	/	/	3.30	1.86	/	/	/	/	/
50	23.38	34.02	38.40	/	/	/	/	2.21	2.40	5.03	/	/	/	/
51	22.74	43.66	/	/	/	/	/	3.21	11.65	/	/	/	/	/
52	23.59	27.14	/	/	/	/	/	4.95	10.60	/	/	/	/	/
53	23.56	34.35	/	/	/	/	/	4.58	9.72	/	/	/	/	/
54	13.89	20.48	32.97	37.84	48.81	/	/	0.61	-0.26	4.65	3.46	3.33	/	/
55	23.58	33.15	42.76	/	/	/	/	2.49	3.01	3.76	/	/	/	/
56	13.80	20.93	22.88	41.63	/	/	/	0.14	0.48	3.08	4.65	/	/	/
57	22.64	39.92	/	/	/	/	/	1.76	5.57	/	/	/	/	/
58	25.15	25.29	42.27	/	/	/	/	6.25	10.09	6.27	/	/	/	/
59	13.82	21.37	29.63	35.96	46.07	56.56	/	0.33	0.17	5.90	2.46	2.73	3.78	/
60	22.23	26.71	34.04	42.20	/	/	/	3.35	14.25	6.86	7.15	/	/	/
61	13.76	27.08	34.37	/	/	/	/	-0.01	2.80	1.06	/	/	/	/
62	23.29	31.78	36.20	43.85	/	/	/	2.64	5.30	3.25	6.97	/	/	/
63	21.89	40.73	/	/	/	/	/	1.26	3.29	/	/	/	/	/
64	13.42	20.14	19.32	29.69	49.67	60.37	/	0.14	-0.03	1.36	3.11	2.87	4.09	/
65	13.54	26.52	48.83	/	/	/	/	0.10	0.94	6.36	/	/	/	/
66	13.52	44.50	44.15	/	/	/	/	-0.04	-0.66	4.55	/	/	/	/
67	13.99	22.40	34.68	/	/	/	/	0.20	2.25	1.30	/	/	/	/
68	14.05	26.56	26.81	45.25	/	/	/	-0.03	-0.13	1.61	1.20	/	/	/
69	13.71	20.55	19.79	28.32	46.23	52.48	/	-0.14	-0.24	2.53	3.47	5.11	6.55	/
70	22.09	31.84	33.47	45.25	/	/	/	3.76	2.05	3.41	3.16	/	/	/
71	13.98	23.41	21.93	32.60	47.78	/	/	1.75	2.34	7.76	2.82	3.29	/	/
72	13.92	21.49	26.98	36.87	51.05	/	/	0.14	0.34	2.28	2.25	3.45	/	/
73	20.29	27.77	24.68	44.52	/	/	/	1.92	2.46	6.93	3.10	/	/	/
74	13.51	21.76	19.48	41.80	/	/	/	0.06	-0.13	2.26	2.86	/	/	/
75	23.12	51.24	/	/	/	/	/	4.47	5.83	/	/	/	/	/
76	22.56	42.64	/	/	/	/	/	2.11	3.50	/	/	/	/	/
77	21.11	27.19	34.16	45.85	/	/	/	1.89	1.82	12.64	2.23	/	/	/
78	23.46	44.78	/	/	/	/	/	7.27	5.80	/	/	/	/	/
79	13.68	21.46	21.27	29.94	41.20	51.79	/	0.10	0.09	1.73	2.40	2.80	3.51	/
80	13.53	20.66	21.62	39.02	56.00	/	/	0.08	-0.20	4.07	4.66	2.39	/	/
81	15.61	40.78	49.77	/	/	/	/	1.41	2.04	2.17	/	/	/	/
82	23.99	31.88	37.29	52.05	/	/	/	3.27	2.98	3.63	4.67	/	/	/
83	13.54	26.71	34.38	51.84	/	/	/	-0.06	1.13	1.77	2.13	/	/	/
84	13.88	22.30	36.09	40.01	/	/	/	0.41	1.06	2.79	2.88	/	/	/
85	14.29	26.61	33.08	44.06	/	/	/	0.11	4.35	0.77	2.37	/	/	/
86	13.80	22.70	31.17	39.92	49.73	/	/	0.27	1.20	2.05	2.87	4.17	/	/
87	24.84	41.73	46.25	/	/	/	/	6.48	7.63	2.00	/	/	/	/
88	13.82	21.31	24.77	33.01	49.87	/	/	0.25	-0.01	1.89	6.54	3.64	/	/
89	23.75	35.27	42.04	/	/	/	/	1.81	3.71	1.14	/	/	/	/
90	23.41	/	/	/	/	/	/	4.91	/	/	/	/	/	/
91	24.32	/	/	/	/	/	/	6.21	/	/	/	/	/	/
92	13.89	21.70	28.03	40.72	51.79	/	/	1.35	0.57	2.00	2.67	2.75	/	/
93	21.47	27.28	36.25	45.61	/	/	/	1.60	2.09	2.44	5.63	/	/	/
94	29.36	38.10	/	/	/	/	/	6.46	9.19	/	/	/	/	/
95	21.40	37.92	37.87	50.46	/	/	/	2.34	6.42	4.10	2.18	/	/	/
96	15.29	22.94	26.91	43.26	/	/	/	1.15	2.97	7.09	4.07	/	/	/
97	14.31	25.97	24.77	31.01	53.96	/	/	0.55	1.56	17.18	9.45	3.44	/	/
98	22.40	32.87	/	/	/	/	/	2.25	7.17	/	/	/	/	/
99	13.82	27.93	30.70	43.01	/	/	/	0.00	0.25	0.68	2.32	/	/	/
100	22.68	42.24	/	/	/	/	/	2.61	2.16	/	/	/	/	/

Appendix Table B.9b Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 500 length measurements using the two partitions for grouping the European hake data.

	Sample size = 500 length measurements													
	Estimates													
	2 cm													
	mean 1 (cm)	*mean 2* (cm)	*mean 3* (cm)	*mean 4* (cm)	*mean 5* (cm)	*mean 6* (cm)	*mean 7* (cm)	*SD 1* (cm)	*SD 2* (cm)	*SD 3* (cm)	*SD 4* (cm)	*SD 5* (cm)	*SD 6* (cm)	*SD 7* (cm)
1	18.96	34.23	45.52	56.07	59.11	/	/	1.56	2.65	1.43	0.98	0.56	/	/
2	18.93	28.91	36.66	42.11	48.50	58.76	/	1.26	2.49	1.36	1.69	0.96	1.06	/
3	19.64	29.31	38.45	43.19	51.47	63.92	/	1.10	3.06	1.70	1.00	1.60	1.35	/
4	19.06	27.90	35.58	42.56	49.48	55.75	/	1.45	2.50	2.46	1.39	1.70	1.43	/
5	18.76	29.38	35.90	42.70	48.50	57.33	/	1.38	2.56	2.37	1.59	1.01	1.51	/
6	19.19	28.38	35.66	45.56	53.20	/	/	1.32	2.47	2.07	1.54	1.48	/	/
7	18.39	28.68	34.66	42.64	50.02	56.89	/	2.06	2.40	1.68	1.41	1.89	1.15	/
8	19.48	28.82	38.05	51.85	56.01	59.77	/	1.11	2.76	2.12	1.20	1.30	1.76	/
9	18.82	28.64	36.26	45.09	50.92	57.93	63.00	1.38	3.94	1.79	1.46	1.58	1.20	0.60
10	19.10	28.66	35.78	41.99	48.50	59.00	/	1.49	2.88	1.86	1.30	1.05	0.77	/
11	18.70	28.28	35.41	41.64	48.76	63.50	/	1.60	2.10	1.34	2.11	1.23	1.20	/
12	18.87	27.39	37.21	44.89	51.78	60.91	/	1.24	2.09	2.31	1.31	0.88	1.86	/
13	18.57	28.68	40.72	47.44	50.61	57.49	/	1.57	2.31	1.51	3.95	1.17	1.42	/
14	18.87	27.67	35.43	44.08	50.89	/	/	1.75	1.92	1.46	1.52	1.70	/	/
15	18.91	28.77	36.24	43.06	51.79	/	/	1.72	3.91	1.22	2.42	1.30	/	/
16	18.71	28.13	33.74	47.00	57.50	/	/	1.28	2.26	1.28	2.61	1.01	/	/
17	19.04	27.75	39.31	42.22	48.93	55.00	65.23	1.47	1.87	1.86	1.97	1.57	0.85	0.82
18	19.16	28.27	36.99	54.36	58.15	61.24	65.00	1.66	2.48	2.45	1.56	1.35	1.37	0.67
19	19.25	29.27	35.85	47.73	52.50	57.23	/	1.49	2.49	1.72	1.73	1.15	0.82	/
20	19.23	27.30	37.71	43.23	52.21	57.89	/	1.40	2.32	1.53	1.06	1.11	1.03	/
21	18.92	28.49	42.06	51.57	61.58	/	/	1.04	2.45	2.39	1.79	1.77	/	/
22	19.54	28.55	41.79	42.95	48.88	63.00	/	0.96	2.64	1.64	1.20	1.08	0.60	/
23	19.20	27.86	35.23	52.27	54.09	60.20	/	1.25	3.00	2.42	1.26	1.43	1.48	/
24	18.77	28.56	36.58	48.01	57.41	/	/	1.20	2.42	1.40	2.25	1.11	/	/
25	18.66	28.53	36.76	43.14	54.98	64.34	/	1.83	2.65	1.54	1.65	1.57	1.29	/
26	18.77	26.43	35.69	40.70	49.92	57.21	/	1.27	1.95	1.49	1.25	2.76	1.11	/
27	19.39	27.29	35.74	42.75	48.50	58.73	/	1.82	1.98	1.05	2.37	1.58	1.29	/
28	18.65	29.15	34.51	41.61	48.41	61.50	/	1.04	3.07	1.10	1.51	1.22	1.23	/
29	18.95	28.47	34.74	43.08	50.16	56.99	/	1.28	2.29	1.04	1.09	1.21	2.51	/
30	18.62	27.81	35.50	43.10	49.88	60.12	/	1.19	2.33	1.32	3.19	1.05	0.59	/
31	18.82	27.69	36.65	42.89	48.62	63.27	/	1.13	2.21	2.25	1.98	1.96	1.00	/
32	18.83	28.95	40.72	44.33	51.60	/	/	1.67	2.92	1.56	1.12	1.80	/	/
33	19.10	28.13	36.45	41.96	52.66	59.50	64.50	1.41	2.39	1.36	1.57	1.61	0.85	1.20
34	19.20	28.63	36.52	43.01	48.69	56.78	/	1.47	2.79	2.36	2.33	1.20	1.18	/
35	18.92	27.17	35.67	46.02	48.78	56.53	63.27	1.35	1.82	1.91	1.54	2.06	1.51	1.51
36	19.07	28.85	34.64	41.75	48.65	/	/	1.51	1.93	1.70	1.28	0.82	/	/
37	18.84	28.56	40.70	43.16	56.09	/	/	1.35	2.70	1.35	1.23	1.43	/	/
38	18.88	28.20	39.89	41.51	49.08	63.50	/	1.13	2.58	1.40	1.45	1.06	0.85	/
39	18.95	29.32	36.36	41.42	48.38	56.61	/	1.35	2.43	1.14	1.27	1.10	1.33	/
40	19.40	27.76	36.06	46.02	49.13	59.98	64.30	1.62	1.76	2.85	1.54	1.43	1.06	1.41
41	19.43	27.76	39.91	40.95	53.27	59.24	/	1.66	2.01	4.99	2.24	2.99	1.06	/
42	19.84	29.81	39.18	42.86	52.65	57.11	/	0.86	2.73	2.22	1.40	1.55	1.03	/
43	19.08	28.58	36.04	43.05	50.91	56.50	/	1.17	2.60	1.33	1.26	1.39	0.92	/
44	18.81	28.74	36.34	41.99	49.92	62.12	/	1.58	2.23	1.33	1.04	1.51	1.13	/
45	18.73	26.87	37.46	42.22	49.01	57.50	/	1.23	2.16	1.93	1.33	1.23	0.96	/
46	19.22	29.62	34.81	41.06	48.03	/	/	1.29	3.46	4.88	1.14	1.78	/	/
47	18.88	28.03	37.52	41.22	48.39	56.50	/	1.66	2.24	2.22	1.23	1.26	1.40	/
48	18.83	27.95	35.81	26.50	50.76	61.48	/	1.29	2.71	1.64	8.51	1.78	1.35	/
49	18.78	26.78	34.55	47.46	52.84	65.50	/	1.37	3.01	3.12	2.30	1.72	1.06	/
50	19.38	28.58	41.08	47.52	51.22	62.64	/	1.27	2.39	4.71	1.27	1.18	1.21	/
51	18.44	28.63	38.08	44.15	51.89	58.73	/	1.43	2.49	2.20	1.08	1.32	1.20	/
52	18.74	28.70	39.49	45.88	48.92	60.09	67.91	1.21	2.70	1.96	1.29	1.26	1.43	1.86
53	18.77	28.81	35.88	43.31	49.04	58.17	/	1.58	2.06	1.12	1.34	1.11	0.69	/
54	19.18	29.03	35.53	46.08	50.33	60.02	/	1.55	1.81	1.73	2.06	1.87	1.91	/
55	19.09	28.07	35.68	42.13	48.50	57.28	/	1.30	2.63	2.33	2.03	1.40	1.29	/
56	18.92	27.05	36.27	41.24	49.50	58.21	/	1.29	1.90	1.65	4.07	1.02	1.01	/
57	18.82	28.60	35.54	42.51	49.26	58.60	/	1.28	2.94	2.45	1.26	1.01	1.80	/
58	18.63	29.44	37.63	46.08	55.75	/	/	1.70	2.45	1.15	1.21	1.43	/	/
59	18.76	34.96	39.06	44.02	49.10	61.97	/	1.21	2.14	1.12	1.59	1.47	0.93	/
60	19.29	28.65	33.78	39.54	50.04	57.39	63.24	1.58	2.23	1.32	1.46	2.04	2.46	1.06
61	18.68	27.63	36.77	41.05	53.00	59.50	/	1.48	2.14	1.13	1.26	0.97	1.23	/
62	18.96	29.87	36.15	42.08	49.69	/	/	1.28	3.67	1.58	1.21	1.19	/	/
63	18.98	28.78	35.56	43.35	51.36	56.00	/	1.24	2.81	1.78	1.45	1.66	1.65	/
64	18.58	27.59	34.60	41.99	48.00	58.29	/	1.35	3.08	2.29	3.09	0.99	1.48	/
65	18.97	29.22	34.93	42.87	47.96	57.50	/	1.47	2.37	1.21	1.41	0.95	1.35	/
66	18.67	27.67	34.88	40.63	50.19	56.25	/	1.41	2.15	1.09	1.41	1.62	1.43	/
67	18.87	28.37	35.80	48.12	48.23	57.94	/	1.51	2.87	5.38	3.21	1.60	1.62	/
68	18.87	29.04	34.77	45.62	49.19	61.24	/	1.38	2.76	2.27	1.09	1.16	1.06	/
69	19.00	28.48	41.08	45.93	48.81	56.30	/	1.42	2.69	1.20	1.04	1.15	0.92	/
70	18.94	29.31	35.81	46.60	57.46	64.17	/	1.15	3.04	1.48	1.17	1.34	1.20	/
71	19.02	28.25	37.27	45.22	51.32	/	/	1.26	2.65	2.06	1.50	1.14	/	/
72	18.77	28.80	41.35	47.96	62.00	/	/	1.24	2.39	2.17	1.60	0.74	/	/
73	19.40	27.29	35.32	41.79	49.04	57.69	/	1.39	2.12	2.17	1.25	1.00	2.41	/
74	18.79	27.52	37.09	48.12	51.84	59.76	/	1.48	2.24	1.31	1.49	1.06	1.19	/
75	19.03	28.06	34.77	43.98	54.34	63.50	/	1.62	2.11	2.64	2.04	1.35	0.98	/
76	19.20	28.94	36.90	49.06	66.88	/	/	1.43	3.18	4.02	1.81	9.41	/	/
77	19.36	28.70	38.86	44.02	54.88	57.11	/	1.05	2.41	2.62	1.49	1.28	1.65	/
78	19.30	28.98	35.14	42.34	49.81	62.73	/	1.17	2.44	1.39	3.91	1.35	1.29	/
79	18.90	29.32	36.77	47.07	56.34	62.41	/	1.51	2.13	1.37	1.42	1.35	3.20	/
80	18.88	27.88	37.37	40.93	48.99	58.08	64.58	1.44	2.16	1.64	1.23	1.18	1.35	2.00
81	19.06	29.60	35.05	40.25	46.95	61.50	/	1.45	3.25	1.31	1.42	1.23	1.35	/
82	19.18	28.75	35.85	43.63	53.07	56.11	/	1.31	2.73	2.96	1.58	1.18	0.75	/
83	19.57	28.48	45.16	53.42	55.50	58.09	/	0.89	2.37	4.01	1.06	1.20	1.43	/
84	18.80	27.60	36.66	42.71	50.50	60.21	/	1.23	2.19	1.57	1.01	1.06	1.57	/
85	18.82	27.83	35.30	42.15	50.50	60.98	/	1.43	2.05	1.41	1.22	0.95	1.91	/
86	18.74	27.41	34.96	41.55	53.28	57.15	65.92	1.36	2.07	1.73	2.68	1.29	1.23	1.35
87	18.73	28.23	34.19	40.54	52.50	57.97	64.00	1.58	2.89	2.67	1.43	1.35	1.20	0.85
88	19.51	28.60	34.64	43.00	47.94	56.50	/	1.23	2.85	1.39	0.92	1.35	0.95	/
89	18.91	28.00	49.29	52.62	55.55	/	/	1.46	1.87	1.48	0.93	2.06	/	/
90	19.15	29.49	37.40	44.17	50.94	59.73	65.17	1.68	2.51	1.39	1.35	1.35	1.00	1.20
91	18.99	28.66	37.99	47.24	53.40	57.85	65.00	1.48	2.41	3.53	1.37	1.54	1.82	0.67
92	19.52	29.42	35.32	41.69	54.12	58.20	/	1.15	3.46	1.62	1.07	1.01	1.29	/
93	18.74	28.47	35.87	43.41	53.80	57.50	/	0.97	2.78	1.81	1.51	1.51	1.35	/
94	18.82	28.01	35.91	42.56	51.95	64.99	/	1.43	2.36	1.99	2.22	0.89	1.90	/
95	19.00	28.46	42.17	43.30	49.94	61.50	/	1.23	2.71	1.57	1.25	1.30	1.06	/
96	18.98	29.58	35.99	42.16	52.91	60.57	/	1.16	2.46	2.06	1.40	1.43	1.48	/
97	19.13	27.15	34.14	44.23	48.50	55.89	/	1.49	2.14	1.59	2.29	1.01	1.36	/
98	18.42	27.83	35.16	48.42	56.30	/	/	1.66	2.24	1.57	1.78	0.92	/	/
99	18.75	28.30	35.21	40.77	49.16	52.76	65.91	1.33	2.29	2.02	1.17	1.76	1.84	1.86
100	18.90	28.03	40.99	44.74	48.69	58.29	63.27	1.35	2.81	1.52	1.37	1.70	0.95	1.51

Appendix Table B.9c Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 500 length measurements using the two partitions for grouping the European hake data.

	Sample size = 500 length measurements													
	% Bias													
	Birgè and Rozenholc algorithm													
	mean 1	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*mean 7*	*SD 1*	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*	*SD 7*
1	-1.24	1.15	2.48	/	/	/	/	-0.56	4.71	-6.48	/	/	/	/
2	-0.73	-0.06	2.70	/	/	/	/	8.50	5.20	5.52	/	/	/	/
3	11.03	5.87	/	/	/	/	/	14.51	14.45	/	/	/	/	/
4	7.95	5.96	4.26	/	/	/	/	14.04	23.02	24.39	/	/	/	/
5	8.75	3.62	4.00	/	/	/	/	13.73	12.62	1.39	/	/	/	/
6	8.79	3.16	4.47	/	/	/	/	8.64	14.48	8.83	/	/	/	/
7	9.68	2.87	2.17	/	/	/	/	34.64	38.73	60.63	/	/	/	/
8	9.10	1.43	3.78	/	/	/	/	7.73	13.88	4.68	/	/	/	/
9	-1.06	-0.24	2.34	9.71	/	/	/	1.95	7.04	18.60	0.49	/	/	/
10	9.77	5.25	/	/	/	/	/	32.10	18.63	/	/	/	/	/
11	-1.29	3.13	2.60	7.16	/	/	/	0.47	-1.31	-9.38	-4.28	/	/	/
12	-0.91	1.08	1.30	6.51	/	/	/	-0.15	33.99	4.51	-12.22	/	/	/
13	-1.14	0.11	0.58	2.74	4.91	/	/	3.84	7.42	17.80	16.97	3.06	/	/
14	10.83	1.42	3.42	/	/	/	/	20.39	34.89	34.80	/	/	/	/
15	42.21	/	/	/	/	/	/	36.07	/	/	/	/	/	/
16	-1.72	-0.21	1.98	6.53	/	/	/	0.12	1.42	31.59	-2.26	/	/	/
17	-1.18	0.01	1.64	5.22	8.23	/	/	0.87	9.17	17.08	17.26	6.07	/	/
18	36.96	/	/	/	/	/	/	55.48	/	/	/	/	/	/
19	8.76	2.31	2.58	7.35	/	/	/	11.84	20.24	8.57	8.07	/	/	/
20	-0.37	0.46	0.65	2.63	5.85	/	/	2.94	14.25	27.37	13.90	2.34	/	/
21	9.20	0.69	1.63	7.72	/	/	/	19.07	13.09	58.20	18.57	/	/	/
22	11.34	2.46	/	/	/	/	/	21.16	39.34	/	/	/	/	/
23	7.93	0.48	2.53	8.12	/	/	/	18.81	44.46	23.92	4.96	/	/	/
24	8.96	2.36	2.51	/	/	/	/	15.65	9.23	21.41	/	/	/	/
25	-0.66	-0.11	0.73	4.26	3.01	/	/	7.52	3.68	34.33	-0.97	-1.96	/	/
26	12.19	4.02	3.13	/	/	/	/	53.12	40.12	70.94	/	/	/	/
27	8.35	2.82	2.65	7.59	/	/	/	12.95	13.46	41.43	18.52	/	/	/
28	-0.83	0.03	2.17	5.90	6.13	/	/	1.35	6.16	-1.65	-3.51	-4.81	/	/
29	-0.96	-0.23	1.25	3.66	4.41	/	/	0.83	0.14	5.42	2.43	-2.82	/	/
30	-0.43	0.17	/	/	/	/	/	115.12	96.83	/	/	/	/	/
31	-0.79	-0.17	1.13	4.34	7.10	/	/	2.01	1.93	95.24	0.76	-6.31	/	/
32	-1.08	-0.23	1.16	5.35	7.56	/	/	3.80	3.91	34.59	-5.87	-6.55	/	/
33	8.87	2.80	1.60	8.61	/	/	/	31.50	23.04	24.27	4.46	/	/	/
34	-1.12	-0.16	-0.05	4.52	5.38	/	/	0.55	1.37	6.27	-6.24	-11.23	/	/
35	11.39	4.77	/	/	/	/	/	22.27	31.25	/	/	/	/	/
36	-1.18	-0.29	-0.25	0.10	7.68	/	/	1.86	2.92	20.92	3.32	3.77	/	/
37	11.45	1.37	/	/	/	/	/	36.25	71.58	/	/	/	/	/
38	-0.95	2.89	2.43	9.75	/	/	/	-1.00	9.87	-1.74	7.92	/	/	/
39	-1.00	-0.11	0.95	2.60	2.57	2.97	/	2.00	3.85	3.10	5.81	-0.13	-8.18	/
40	11.78	7.51	/	/	/	/	/	16.49	16.18	/	/	/	/	/
41	9.56	1.89	3.75	/	/	/	/	12.83	14.40	24.63	/	/	/	/
42	11.23	4.92	/	/	/	/	/	9.63	35.90	/	/	/	/	/
43	12.14	6.65	/	/	/	/	/	16.93	14.22	/	/	/	/	/
44	8.67	2.62	2.23	8.67	/	/	/	32.67	6.31	16.41	13.12	/	/	/
45	10.22	3.39	2.34	10.60	/	/	/	24.12	31.23	46.32	2.26	/	/	/
46	-1.69	-0.01	2.79	/	/	/	/	0.88	6.13	16.40	/	/	/	/
47	-1.10	0.01	0.92	2.45	/	/	/	2.25	3.19	8.87	8.18	/	/	/
48	-0.91	1.40	1.02	9.01	/	/	/	-0.46	3.03	2.07	-9.72	/	/	/
49	10.47	3.99	/	/	/	/	/	23.47	11.66	/	/	/	/	/
50	11.22	2.85	2.98	/	/	/	/	15.92	14.41	43.22	/	/	/	/
51	10.40	5.07	/	/	/	/	/	22.83	62.13	/	/	/	/	/
52	11.50	1.26	/	/	/	/	/	34.93	56.69	/	/	/	/	/
53	11.46	2.92	/	/	/	/	/	32.37	52.14	/	/	/	/	/
54	-1.01	-0.28	2.06	3.86	5.01	/	/	4.80	0.73	39.16	8.94	-0.87	/	/
55	11.49	2.65	3.71	/	/	/	/	17.87	17.56	29.48	/	/	/	/
56	-1.13	-0.17	0.36	5.55	/	/	/	1.54	4.52	22.16	19.63	/	/	/
57	10.28	4.21	/	/	/	/	/	12.79	30.76	/	/	/	/	/
58	13.51	0.83	3.63	/	/	/	/	43.93	54.09	56.54	/	/	/	/
59	-1.09	-0.07	1.50	3.01	3.56	3.58	/	2.87	2.95	52.54	-0.08	-5.49	-13.28	/
60	9.75	1.16	2.24	5.81	/	/	/	23.81	75.51	62.95	42.06	/	/	/
61	-1.17	1.25	2.30	/	/	/	/	0.49	16.47	0.41	/	/	/	/
62	11.11	2.33	2.61	6.55	/	/	/	18.91	29.37	23.98	40.49	/	/	/
63	9.31	4.40	/	/	/	/	/	9.31	19.04	/	/	/	/	/
64	-1.61	-0.36	-0.24	0.21	5.47	5.35	/	1.51	1.91	3.62	5.75	-4.42	-11.13	/
65	-1.46	1.12	4.74	/	/	/	/	1.23	6.90	57.50	/	/	/	/
66	-1.49	5.27	3.95	/	/	/	/	0.26	-1.34	38.04	/	/	/	/
67	-0.87	0.17	2.35	/	/	/	/	1.94	13.66	3.04	/	/	/	/
68	-0.81	1.13	1.02	7.17	/	/	/	0.34	1.39	6.35	-11.40	/	/	/
69	-1.23	-0.26	-0.16	-0.41	3.65	1.68	/	-0.40	0.82	16.22	9.01	12.82	5.59	/
70	9.57	2.35	2.15	7.17	/	/	/	26.69	12.63	25.71	6.19	/	/	/
71	-0.89	0.40	0.20	1.51	4.47	/	/	12.69	14.13	72.67	3.13	-1.13	/	/
72	-0.97	-0.04	1.05	3.42	6.20	/	/	1.53	3.80	13.62	-1.95	0.09	/	/
73	7.25	1.41	0.66	6.85	/	/	/	13.89	14.77	63.68	5.69	/	/	/
74	-1.50	0.02	-0.22	5.63	/	/	/	0.95	1.41	13.37	3.48	/	/	/
75	10.89	6.82	/	/	/	/	/	31.58	32.10	/	/	/	/	/
76	10.17	4.84	/	/	/	/	/	15.23	20.09	/	/	/	/	/
77	8.31	1.27	2.26	7.44	/	/	/	13.65	11.46	125.21	-2.17	/	/	/
78	11.33	5.33	/	/	/	/	/	51.06	31.93	/	/	/	/	/
79	-1.28	-0.05	0.09	0.32	0.97	1.36	/	1.24	2.54	7.61	-0.64	-4.95	-15.05	/
80	-1.46	-0.24	0.15	4.39	8.83	/	/	1.14	1.02	32.86	19.67	-8.06	/	/
81	1.21	4.41	4.90	/	/	/	/	10.36	12.55	12.41	/	/	/	/
82	12.02	2.36	2.79	10.22	/	/	/	23.23	17.40	28.11	19.78	/	/	/
83	-1.45	1.16	2.30	10.12	/	/	/	0.17	7.89	8.09	-3.06	/	/	/
84	-1.01	0.14	2.59	4.83	/	/	/	3.38	7.52	19.04	3.65	/	/	/
85	-0.49	1.14	2.08	6.64	/	/	/	1.34	24.49	-2.74	-0.88	/	/	/
86	-1.12	0.23	1.76	4.78	5.50	/	/	2.41	8.22	11.14	3.56	5.59	/	/
87	13.11	4.63	4.30	/	/	/	/	45.59	41.41	10.53	/	/	/	/
88	-1.10	-0.09	0.68	1.69	5.58	/	/	2.26	1.99	9.41	36.63	1.54	/	/
89	11.71	3.14	3.59	/	/	/	/	13.09	21.20	1.30	/	/	/	/
90	11.27	/	/	/	/	/	/	34.65	/	/	/	/	/	/
91	12.44	/	/	/	/	/	/	43.68	/	/	/	/	/	/
92	-1.01	0.00	1.23	5.14	6.59	/	/	9.94	4.98	10.56	1.81	-5.31	/	/
93	8.77	1.29	2.62	7.33	/	/	/	11.66	12.82	15.29	28.45	/	/	/
94	18.93	3.79	/	/	/	/	/	45.40	49.42	/	/	/	/	/
95	8.67	3.75	2.89	9.51	/	/	/	16.79	35.17	33.22	-2.57	/	/	/
96	0.80	0.29	1.04	6.28	/	/	/	8.57	17.36	65.39	14.39	/	/	/
97	-0.46	0.99	0.68	0.80	7.74	/	/	4.41	10.11	174.12	62.73	0.01	/	/
98	9.96	2.58	/	/	/	/	/	16.20	39.00	/	/	/	/	/
99	-1.09	1.44	1.68	6.17	/	/	/	0.54	3.37	-3.65	-1.33	/	/	/
100	10.33	4.75	/	/	/	/	/	18.68	13.20	/	/	/	/	/

Appendix Table B.9d Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 500 length measurements using the two partitions for grouping the European hake data.

	Sample size = 500 length measurements													
	% Bias													
	2 cm													
	mean 1	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*mean 7*	*SD 1*	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*	*SD 7*
1	-2.22	79.11	138.54	53.60	25.39	/	/	8.34	-3.95	-38.45	-64.72	-82.80	/	/
2	-2.38	0.65	17.33	4.61	2.89	9.48	/	-12.58	-20.76	-41.30	-39.12	-70.39	-71.29	/
3	1.31	6.51	41.88	8.39	9.19	19.10	/	-23.93	37.85	-26.78	-64.16	-50.73	-63.34	/
4	-1.72	-14.31	2.61	6.19	4.97	3.88	/	0.78	-19.76	5.92	-49.87	-47.62	-61.20	/
5	-3.25	7.54	6.93	6.69	2.89	6.82	/	-3.86	-13.19	2.15	-42.71	-68.81	-58.93	/
6	-1.01	-7.23	3.65	16.69	12.87	/	/	-8.42	-22.82	-10.84	-44.73	-54.54	/	/
7	-5.14	-2.83	-10.02	6.47	6.10	5.99	/	43.30	-29.68	-27.60	-49.36	-41.83	-68.66	/
8	0.44	-0.74	36.33	38.78	18.81	11.37	/	-22.76	7.47	-8.51	-56.87	-60.11	-52.19	/
9	-2.92	-3.35	11.86	15.04	8.02	7.93	1.61	-4.14	128.38	-22.65	-47.63	-51.30	-67.42	-85.77
10	-1.49	-3.13	5.35	4.17	2.89	9.93	/	3.23	19.72	-19.93	-53.24	-67.82	-79.13	/
11	-3.54	-8.67	0.22	2.94	3.44	18.32	/	11.10	-61.10	-42.38	-23.97	-62.25	-67.36	/
12	-2.66	-21.86	24.88	14.38	9.85	13.49	/	-13.82	-61.77	-0.60	-52.83	-72.96	-49.34	/
13	-4.24	-2.86	72.88	23.32	7.36	7.11	/	8.99	-39.55	-34.85	42.12	-63.93	-61.31	/
14	-2.70	-17.79	0.51	11.51	7.95	/	/	21.50	-79.66	-36.94	-45.40	-47.73	/	/
15	-2.47	-1.46	11.60	7.95	9.86	/	/	19.54	126.00	-47.45	-12.88	-59.92	/	/
16	-3.49	-10.87	-22.54	21.77	21.98	/	/	-10.77	-44.24	-44.74	-6.19	-68.81	/	/
17	-1.81	-16.50	53.60	4.98	3.80	2.48	5.21	2.37	-84.06	-19.64	-29.20	-51.68	-76.92	-80.68
18	-1.18	-8.82	21.95	47.61	23.36	14.11	4.84	14.98	-21.75	5.42	-43.73	-58.42	-62.90	-84.01
19	-0.70	5.87	6.32	24.31	11.37	6.63	/	3.66	-20.15	-25.83	-37.62	-64.52	-77.84	/
20	-0.80	-23.14	31.77	8.52	10.76	7.86	/	-2.51	-37.63	-34.17	-61.76	-65.70	-72.10	/
21	-2.43	-5.62	91.27	37.82	30.62	/	/	-27.67	-24.41	3.15	-35.63	-45.56	/	/
22	0.77	-4.73	87.53	7.54	3.69	17.38	/	-33.17	-5.43	-29.23	-56.79	-66.85	-83.68	/
23	-1.00	-14.92	-2.16	40.25	14.74	12.18	/	-13.06	32.29	4.32	-54.55	-56.06	-59.85	/
24	-3.19	-4.52	16.34	25.29	21.78	/	/	-16.91	-27.50	-39.60	-18.97	-65.96	/	/
25	-3.77	-4.96	18.79	8.22	16.64	19.88	/	27.24	-4.03	-33.78	-40.56	-51.60	-64.84	/
26	-3.18	-36.07	4.13	-0.35	5.89	6.60	/	-11.58	-76.17	-35.61	-55.11	-14.96	-69.71	/
27	0.00	-23.34	4.73	6.83	2.89	9.43	/	26.35	-73.42	-54.79	-14.82	-51.30	-64.84	/
28	-3.84	4.08	-11.97	2.84	2.68	14.59	/	-28.01	39.47	-52.67	-45.66	-62.61	-66.57	/
29	-2.27	-5.92	-8.88	8.01	6.41	6.18	/	-10.95	-40.72	-55.21	-60.68	-62.66	-31.91	/
30	-3.96	-15.64	1.50	8.06	5.82	12.02	/	-17.06	-37.00	-43.22	14.62	-67.68	-84.02	/
31	-2.94	-17.50	17.29	7.34	3.13	17.89	/	-21.71	-49.98	-3.19	-28.82	-39.84	-72.93	/
32	-2.88	1.22	72.88	12.38	9.46	/	/	16.29	23.54	-32.96	-59.78	-44.61	/	/
33	-1.52	-10.90	14.47	4.07	11.71	10.86	4.03	-2.38	-30.90	-41.24	-43.51	-50.47	-76.92	-71.54
34	-0.96	-3.55	15.49	7.76	3.30	5.80	/	2.36	10.63	1.84	-16.11	-63.04	-67.83	/
35	-2.44	-25.08	3.81	18.32	3.47	5.34	2.06	-6.25	-89.49	-17.62	-44.47	-36.53	-58.86	-64.18
36	-1.63	-0.30	-10.31	3.34	3.21	/	/	5.14	-78.05	-26.78	-53.80	-74.86	/	/
37	-2.86	-4.51	72.69	8.29	18.98	/	/	-6.14	1.53	-41.84	-55.68	-56.06	/	/
38	-2.65	-9.88	61.55	2.50	4.13	18.32	/	-21.62	-11.26	-39.78	-47.99	-67.23	-76.92	/
39	-2.29	6.58	13.20	2.16	2.64	5.48	/	-6.34	-26.30	-50.89	-54.35	-66.21	-63.85	/
40	0.05	-16.32	9.21	18.32	4.23	11.76	3.72	12.39	-95.48	22.99	-44.73	-55.99	-71.29	-66.67
41	0.19	-16.36	61.84	0.51	13.00	10.38	/	15.38	-69.68	115.00	-19.52	-7.85	-71.29	/
42	2.30	13.84	51.89	7.24	11.68	6.42	/	-40.47	3.93	-4.27	-49.74	-52.39	-72.10	/
43	-1.62	-4.23	8.95	7.90	7.99	5.27	/	-18.69	-8.78	-42.78	-54.55	-57.12	-75.13	/
44	-2.98	-1.88	13.06	4.17	5.89	15.75	/	9.58	-47.20	-42.78	-62.66	-53.49	-69.17	/
45	-3.40	-29.59	28.27	4.99	3.96	7.14	/	-14.86	-55.04	-16.63	-52.08	-62.15	-73.91	/
46	-0.87	11.02	-7.98	0.90	1.89	/	/	-10.26	79.28	110.22	-59.15	-45.12	/	/
47	-2.66	-12.37	29.09	1.46	2.66	5.27	/	15.38	-46.10	-4.27	-55.75	-61.12	-61.98	/
48	-2.87	-13.59	5.74	-50.19	7.69	14.55	/	-10.69	2.51	-29.25	206.02	-45.12	-63.34	/
49	-3.17	-30.90	-11.46	23.37	12.10	22.04	/	-5.08	32.55	34.66	-17.41	-47.00	-71.29	/
50	-0.04	-4.26	77.84	23.58	8.65	16.71	/	-11.78	-31.37	103.02	-54.38	-63.57	-67.14	/
51	-4.90	-3.59	36.76	11.76	10.08	9.42	/	-0.46	-20.68	-5.32	-61.04	-59.24	-67.51	/
52	-3.34	-2.46	56.02	17.82	3.77	11.96	9.53	-15.89	0.63	-15.71	-53.64	-61.12	-61.20	-55.82
53	-3.19	-0.93	6.76	8.81	4.04	8.38	/	9.69	-65.22	-51.51	-51.71	-65.70	-81.16	/
54	-1.08	2.36	1.89	18.52	6.77	11.84	/	7.65	-90.60	-25.46	-26.02	-42.59	-48.15	/
55	-1.53	-11.87	4.03	4.67	2.89	6.72	/	-9.52	-6.00	0.57	-27.13	-56.95	-64.98	/
56	-2.45	-26.90	12.03	1.56	5.01	8.45	/	-10.64	-81.88	-28.92	46.32	-68.66	-72.56	/
57	-2.95	-4.04	2.02	6.01	4.50	9.18	/	-11.06	25.82	5.58	-54.55	-68.81	-51.08	/
58	-3.93	8.43	30.65	18.53	18.27	/	/	17.77	-24.94	-50.30	-56.35	-56.06	/	/
59	-3.25	89.94	50.13	11.31	4.17	15.46	/	-16.31	-56.32	-51.51	-42.71	-54.74	-74.67	/
60	-0.53	-3.19	-21.99	-4.41	6.14	6.93	2.00	10.00	-47.81	-43.04	-47.62	-37.30	-33.23	-74.96
61	-3.64	-18.38	18.92	0.88	12.42	10.86	/	2.76	-56.90	-51.33	-54.55	-70.17	-66.57	/
62	-2.21	14.71	10.37	4.49	5.41	/	/	-11.14	101.40	-31.88	-56.35	-63.45	/	/
63	-2.13	-1.37	2.33	8.94	8.95	4.35	/	-14.16	12.27	-23.12	-47.87	-48.95	-55.14	/
64	-4.16	-18.85	-10.75	4.17	1.82	8.61	/	-5.98	39.99	-1.14	11.33	-69.56	-59.85	/
65	-2.18	5.10	-6.26	7.27	1.74	7.14	/	2.15	-33.02	-47.69	-49.38	-70.77	-63.34	/
66	-3.69	-17.79	-7.04	-0.61	6.46	4.80	/	-1.78	-55.76	-52.83	-49.40	-50.26	-61.20	/
67	-2.70	-7.35	5.57	25.71	2.32	7.96	/	4.62	18.29	131.98	15.38	-50.64	-55.96	/
68	-2.67	2.51	-8.43	16.93	4.34	14.11	/	-3.99	7.51	-2.37	-60.68	-64.18	-71.29	/
69	-2.03	-5.82	77.79	18.00	3.54	4.91	/	-1.32	-0.21	-48.23	-62.66	-64.52	-74.94	/
70	-2.33	6.44	5.79	20.38	21.89	19.56	/	-19.89	36.51	-36.16	-57.99	-58.81	-67.36	/
71	-1.89	-9.17	25.65	15.51	8.88	/	/	-12.59	-4.14	-11.08	-46.17	-64.94	/	/
72	-3.21	-1.07	81.47	25.15	31.52	/	/	-13.93	-31.34	-6.60	-42.41	-77.27	/	/
73	0.04	-23.34	-0.97	3.49	4.03	7.49	/	-3.26	-58.72	-6.34	-55.05	-69.34	-34.47	/
74	-3.11	-19.94	23.31	25.71	9.97	11.34	/	2.45	-46.14	-43.48	-46.52	-67.49	-67.60	/
75	-1.87	-11.89	-8.47	11.18	15.28	18.32	/	12.20	-60.07	13.82	-26.76	-58.48	-73.35	/
76	-0.97	1.05	20.68	28.99	41.88	/	/	-0.87	50.85	73.25	-34.85	189.60	/	/
77	-0.13	-2.51	47.50	11.29	16.42	6.41	/	-27.36	-29.30	12.89	-46.52	-60.55	-55.14	/
78	-0.47	1.63	-3.36	5.41	5.66	16.88	/	-18.48	-26.11	-40.10	40.56	-58.48	-64.84	/
79	-2.52	6.66	18.84	22.02	19.52	16.29	/	5.02	-57.82	-41.06	-48.88	-58.48	-13.12	/
80	-2.64	-14.64	27.09	0.44	3.92	8.22	4.15	0.12	-54.28	-29.44	-55.75	-63.57	-63.34	-52.60
81	-1.71	10.80	-4.65	-1.93	-0.41	14.59	/	0.52	58.22	-43.48	-49.06	-62.15	-63.34	/
82	-1.07	-1.71	6.35	9.92	12.59	4.55	/	-8.87	4.08	27.74	-43.08	-63.68	-79.70	/
83	0.92	-5.76	133.67	44.30	17.73	8.23	/	-37.92	-33.32	72.76	-62.00	-63.04	-61.20	/
84	-3.04	-18.82	17.33	6.70	7.13	12.18	/	-14.27	-51.42	-32.31	-63.53	-67.49	-57.32	/
85	-2.96	-15.42	-1.26	4.74	7.13	13.61	/	-0.37	-65.50	-39.09	-56.17	-70.64	-48.15	/
86	-3.33	-21.62	-5.85	2.62	13.02	6.48	6.32	-5.30	-63.92	-25.50	-3.58	-60.34	-66.57	-68.03
87	-3.38	-9.47	-16.35	-0.90	11.37	8.02	3.23	9.40	20.60	15.02	-48.63	-58.48	-67.36	-79.87
88	0.63	-4.01	-10.19	7.71	1.71	5.27	/	-14.30	16.50	-40.27	-66.94	-58.48	-74.07	/
89	-2.49	-12.79	190.05	41.50	17.84	/	/	1.59	-84.42	-36.32	-66.48	-36.53	/	/
90	-1.23	9.21	27.45	11.84	8.07	11.29	5.11	16.55	-18.68	-39.93	-51.47	-58.48	-72.93	-71.54
91	-2.08	-3.14	35.56	22.61	13.28	7.78	4.84	2.82	-28.55	52.27	-50.83	-52.52	-50.45	-84.01
92	0.69	8.18	-0.98	3.11	14.81	8.43	/	-19.84	79.41	-30.09	-61.42	-68.81	-64.84	/
93	-3.37	-5.85	6.55	9.18	14.13	7.14	/	-32.29	9.52	-22.06	-45.78	-53.49	-63.34	/
94	-2.92	-12.74	7.16	6.19	10.20	21.09	/	-0.41	-33.72	-14.36	-20.07	-72.51	-48.35	/
95	-2.03	-6.06	92.78	8.79	5.93	14.59	/	-14.87	1.88	-32.31	-55.05	-59.91	-71.29	/
96	-2.12	10.42	8.25	4.76	12.25	12.85	/	-19.23	-23.90	-11.39	-49.67	-56.06	-59.75	/
97	-1.35	-25.47	-17.06	12.04	2.89	4.14	/	3.77	-56.32	-31.68	-17.66	-68.81	-63.00	/
98	-4.98	-15.43	-3.17	26.75	19.44	/	/	15.00	-46.50	-32.31	-35.84	-71.62	/	/
99	-3.28	-8.36	-2.45	-0.10	4.29	-1.69	6.31	-7.31	-40.85	-12.98	-57.77	-45.89	-49.87	-55.82
100	-2.55	-12.47	76.60	13.82	3.28	8.61	2.06	-6.40	12.20	-34.66	-50.83	-47.73	-74.07	-64.18

Appendix Table B.10a Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 1000 length measurements using the two partitions for grouping the European hake data.

	Sample size = 1000 length measurements													
	Estimates													
	Birgè and Rozenholc algorithm													
	mean 1 (cm)	*mean 2 (cm)*	*mean 3 (cm)*	*mean 4 (cm)*	*mean 5 (cm)*	*mean 6 (cm)*	*mean 7 (cm)*	*SD 1 (cm)*	*SD 2 (cm)*	*SD 3 (cm)*	*SD 4 (cm)*	*SD 5 (cm)*	*SD 6 (cm)*	*SD 7 (cm)*
1	19.52	18.16	23.12	32.06	50.96	/	/	1.05	7.69	1.07	3.07	1.31	/	/
2	19.46	21.14	18.98	34.46	/	/	/	1.44	0.97	2.96	3.85	/	/	/
3	19.51	25.91	35.35	44.09	/	/	/	1.25	1.30	4.34	2.34	/	/	/
4	19.78	22.23	25.99	34.59	42.39	55.70	/	2.01	1.20	2.47	5.34	3.35	4.00	/
5	19.58	24.79	40.26	51.50	/	/	/	1.49	4.22	1.35	1.26	/	/	/
6	19.58	21.66	17.77	24.72	45.56	/	/	1.37	1.01	5.75	3.27	4.84	/	/
7	20.00	27.90	32.97	46.10	/	/	/	1.27	1.64	2.14	4.51	/	/	/
8	29.25	34.76	29.33	40.36	/	/	/	3.79	5.31	9.96	3.69	/	/	/
9	19.55	46.05	49.94	/	/	/	/	1.44	4.18	0.75	/	/	/	/
10	19.51	27.90	39.35	48.81	/	/	/	1.32	7.38	1.12	3.11	/	/	/
11	19.41	26.68	41.21	47.89	/	/	/	1.46	2.99	1.33	3.55	/	/	/
12	19.67	26.86	33.07	45.77	/	/	/	1.29	2.43	1.25	2.37	/	/	/
13	19.86	28.40	25.79	34.34	51.32	/	/	1.16	0.71	1.36	2.75	1.70	/	/
14	19.82	21.42	26.35	42.63	51.95	/	/	1.63	0.83	4.08	2.29	3.72	/	/
15	29.75	26.75	38.62	/	/	/	/	5.63	10.41	5.23	/	/	/	/
16	19.44	29.90	32.84	45.47	/	/	/	1.48	5.22	1.46	2.38	/	/	/
17	19.44	22.74	25.28	40.83	/	/	/	1.49	1.99	3.86	6.61	/	/	/
18	19.71	27.32	33.60	38.47	/	/	/	1.49	1.40	1.17	2.02	/	/	/
19	19.60	21.36	24.79	34.91	51.19	/	/	1.60	0.64	4.58	10.52	5.42	/	/
20	19.40	22.34	27.87	33.62	48.83	/	/	1.57	2.00	3.43	3.39	3.02	/	/
21	19.55	28.79	26.44	35.65	52.22	/	/	1.27	1.13	1.12	1.87	1.16	/	/
22	19.58	22.32	25.43	42.62	51.29	/	/	1.82	1.88	4.75	44.52	3.87	/	/
23	19.55	27.57	35.47	45.25	/	/	/	1.23	3.81	2.64	2.74	/	/	/
24	28.39	40.26	43.89	/	/	/	/	5.43	8.90	4.38	/	/	/	/
25	19.66	21.29	25.60	33.09	41.22	55.64	/	1.61	1.30	3.28	7.73	5.04	3.76	/
26	19.05	22.30	30.44	47.04	/	/	/	1.47	1.80	5.13	2.49	/	/	/
27	19.48	27.24	32.00	40.04	53.43	/	/	1.37	1.75	2.43	2.04	3.30	/	/
28	19.89	22.00	26.72	35.06	50.15	61.18	/	1.39	0.56	2.96	1.97	2.12	2.71	/
29	19.58	21.47	27.97	34.27	46.03	/	/	1.28	0.34	0.95	2.69	2.06	/	/
30	19.74	21.98	23.84	39.75	49.94	/	/	1.09	0.99	0.79	1.70	1.71	/	/
31	19.67	23.22	24.02	30.67	43.81	/	/	2.45	2.33	2.41	3.45	7.68	/	/
32	19.62	29.58	28.45	40.18	/	/	/	1.35	3.30	0.76	2.18	/	/	/
33	19.57	26.72	32.34	43.59	/	/	/	1.32	1.19	3.29	3.91	/	/	/
34	19.98	26.00	37.69	44.68	/	/	/	1.56	4.75	1.66	1.70	/	/	/
35	19.73	26.95	26.11	37.51	52.92	/	/	1.29	0.46	1.16	2.64	2.64	/	/
36	19.57	26.00	31.30	43.72	/	/	/	1.52	2.26	5.33	2.78	/	/	/
37	19.75	28.23	33.96	40.80	/	/	/	1.72	1.85	2.57	1.48	/	/	/
38	19.41	18.74	33.03	48.34	/	/	/	1.32	7.65	2.33	1.65	/	/	/
39	19.67	46.44	49.69	/	/	/	/	1.40	0.52	1.24	/	/	/	/
40	19.35	26.20	33.44	47.98	/	/	/	1.36	5.33	1.90	4.00	/	/	/
41	19.26	43.35	/	/	/	/	/	1.37	5.32	/	/	/	/	/
42	19.32	27.79	38.02	46.44	/	/	/	1.28	1.36	4.02	3.12	/	/	/
43	19.82	27.27	26.91	34.21	47.96	/	/	1.38	1.75	1.28	2.09	1.92	/	/
44	19.43	21.99	17.09	32.01	41.57	53.08	/	1.52	1.21	7.71	6.40	4.33	8.59	/
45	19.27	26.76	36.39	50.14	/	/	/	1.40	2.42	3.36	2.09	/	/	/
46	19.59	26.74	26.66	44.41	/	/	/	1.46	1.37	1.53	3.27	/	/	/
47	19.67	27.52	36.91	41.90	/	/	/	1.50	1.17	0.76	1.83	/	/	/
48	19.86	26.52	26.63	36.42	55.82	/	/	1.39	2.20	1.75	5.18	2.08	/	/
49	19.27	21.24	22.44	30.46	50.90	/	/	1.43	1.38	6.20	7.48	3.78	/	/
50	19.55	22.35	34.87	48.73	/	/	/	1.25	4.26	7.13	2.02	/	/	/
51	19.58	27.37	34.44	42.99	/	/	/	1.41	1.72	4.92	2.35	/	/	/
52	19.73	28.18	28.66	39.37	/	/	/	1.46	3.62	9.93	6.00	/	/	/
53	26.83	32.83	35.95	39.30	/	/	/	3.09	4.76	5.77	4.97	/	/	/
54	19.59	43.05	45.73	/	/	/	/	1.64	3.12	3.29	/	/	/	/
55	19.42	37.99	33.94	46.57	/	/	/	1.23	4.30	5.51	2.09	/	/	/
56	19.41	43.73	46.56	/	/	/	/	1.24	2.50	3.06	/	/	/	/
57	19.55	21.57	27.42	37.66	49.86	/	/	1.30	0.15	3.58	3.06	2.70	/	/
58	19.57	22.05	27.80	34.61	50.57	/	/	1.39	0.38	2.41	2.99	1.60	/	/
59	19.43	22.75	31.61	50.31	/	/	/	1.33	8.87	2.42	3.06	/	/	/
60	19.32	27.35	33.95	47.14	/	/	/	1.38	3.31	1.90	1.99	/	/	/
61	19.89	28.51	35.00	46.21	/	/	/	1.46	4.21	1.30	1.96	/	/	/
62	19.59	27.43	33.36	47.33	/	/	/	1.67	2.63	3.09	1.68	/	/	/
63	19.57	27.02	23.11	42.83	/	/	/	1.29	1.95	6.92	3.64	/	/	/
64	19.50	21.70	32.01	34.38	51.61	/	/	1.86	0.92	7.27	6.58	3.30	/	/
65	19.50	27.72	34.66	43.61	/	/	/	1.45	2.01	4.82	2.97	/	/	/
66	19.38	34.80	34.85	48.10	/	/	/	1.25	1.49	1.94	1.65	/	/	/
67	19.43	26.16	31.32	46.77	/	/	/	1.37	5.98	1.52	1.71	/	/	/
68	19.80	21.87	26.95	31.66	44.10	60.93	/	2.04	1.30	6.52	3.45	5.96	4.53	/
69	19.96	21.38	23.77	34.78	50.00	/	/	1.99	1.31	4.95	6.11	3.69	/	/
70	19.62	27.38	24.00	47.25	/	/	/	1.48	1.66	12.14	3.67	/	/	/
71	19.94	35.86	41.27	/	/	/	/	1.57	6.26	0.42	/	/	/	/
72	19.52	24.08	36.21	41.49	/	/	/	1.47	5.23	2.34	3.20	/	/	/
73	29.70	56.74	/	/	/	/	/	4.96	2.22	/	/	/	/	/
74	19.58	26.54	43.70	/	/	/	/	1.23	1.63	1.95	/	/	/	/
75	27.05	42.98	45.54	/	/	/	/	3.54	8.67	4.52	/	/	/	/
76	19.92	21.60	25.63	26.33	43.78	/	/	1.99	0.94	2.38	10.62	4.01	/	/
77	19.67	42.47	45.34	50.48	/	/	/	1.24	2.69	0.50	2.03	/	/	/
78	19.91	22.42	35.93	38.44	/	/	/	1.50	1.47	1.76	2.27	/	/	/
79	19.48	28.75	36.28	39.82	/	/	/	1.37	3.45	1.99	2.85	/	/	/
80	19.44	23.79	36.20	/	/	/	/	1.40	7.05	1.66	/	/	/	/
81	19.19	21.81	18.38	33.07	48.12	/	/	1.42	1.37	1.92	5.90	4.88	/	/
82	19.48	25.96	27.40	45.00	/	/	/	1.45	1.38	1.88	3.27	/	/	/
83	19.67	29.16	36.38	41.50	/	/	/	1.54	1.61	1.41	2.46	/	/	/
84	19.84	25.07	32.06	46.20	/	/	/	1.69	2.89	1.57	2.70	/	/	/
85	19.64	26.52	34.80	41.46	/	/	/	1.43	3.07	1.35	2.97	/	/	/
86	19.64	27.69	28.05	40.73	/	/	/	1.42	0.88	3.97	1.92	/	/	/
87	19.57	28.10	35.17	47.68	/	/	/	1.41	2.20	1.63	3.42	/	/	/
88	30.85	/	/	/	/	/	/	9.51	/	/	/	/	/	/
89	19.87	26.56	33.94	44.97	/	/	/	1.27	1.15	6.22	1.94	/	/	/
90	19.53	34.41	45.69	/	/	/	/	1.39	1.36	1.51	/	/	/	/
91	19.25	27.67	34.14	/	/	/	/	1.43	3.67	3.39	/	/	/	/
92	28.09	34.99	38.09	/	/	/	/	3.63	9.36	7.18	/	/	/	/
93	19.53	27.25	34.25	41.14	/	/	/	1.50	1.15	0.65	4.36	/	/	/
94	19.75	28.22	35.33	41.02	/	/	/	1.42	2.00	1.42	2.30	/	/	/
95	19.76	27.68	/	/	/	/	/	1.44	2.57	/	/	/	/	/
96	19.74	34.33	34.57	49.90	/	/	/	1.34	2.62	1.22	1.72	/	/	/
97	19.70	26.87	36.54	/	/	/	/	1.73	2.30	0.90	/	/	/	/
98	29.41	/	/	/	/	/	/	6.29	/	/	/	/	/	/
99	19.49	24.27	30.21	49.86	/	/	/	1.43	7.01	7.95	1.97	/	/	/
100	19.44	59.24	/	/	/	/	/	1.47	1.41	/	/	/	/	/

Appendix Table B.10b Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 1000 length measurements using the two partitions for grouping the European hake data.

	Sample size = 1000 length measurements													
	Estimates													
	2 cm													
	mean 1 (cm)	*mean 2 (cm)*	*mean 3 (cm)*	*mean 4 (cm)*	*mean 5 (cm)*	*mean 6 (cm)*	*mean 7 (cm)*	*SD 1 (cm)*	*SD 2 (cm)*	*SD 3 (cm)*	*SD 4 (cm)*	*SD 5 (cm)*	*SD 6 (cm)*	*SD 7 (cm)*
1	18.86	28.12	36.41	43.68	58.82	62.87	/	1.42	2.56	1.64	1.38	1.16	0.99	/
2	18.83	28.22	46.19	52.53	58.61	/	/	1.43	2.66	1.94	1.36	1.15	/	/
3	19.01	27.91	36.08	41.15	55.60	59.32	68.82	1.40	2.02	2.26	5.15	0.87	1.10	1.29
4	19.10	27.80	43.48	49.89	50.90	61.93	/	1.58	1.77	2.96	1.10	1.20	1.21	/
5	19.10	28.25	36.88	42.79	55.77	58.08	/	1.43	2.81	2.28	3.17	1.38	1.35	/
6	18.95	29.05	36.52	43.03	49.13	56.35	65.96	1.23	3.19	2.68	1.80	1.64	2.86	1.15
7	19.08	27.24	37.10	45.44	48.52	58.89	64.65	1.29	1.78	2.82	2.57	1.45	1.65	0.81
8	27.20	35.44	45.54	51.11	59.32	/	/	1.57	1.79	4.71	2.54	1.50	/	/
9	18.98	28.56	36.50	43.72	49.77	57.43	66.44	1.61	2.23	2.54	1.40	2.26	1.90	1.70
10	18.94	27.93	38.11	43.52	50.13	61.02	/	1.34	2.25	2.74	2.97	1.57	2.68	/
11	18.84	27.91	37.61	45.00	52.05	56.77	/	1.32	1.76	1.89	1.64	1.97	1.02	/
12	19.18	28.81	35.88	42.70	52.82	58.31	/	1.56	2.51	2.20	2.04	2.83	0.98	/
13	18.90	28.18	36.64	42.58	56.82	/	/	1.30	2.63	2.78	1.79	1.67	/	/
14	19.09	28.54	36.57	42.67	49.68	58.74	65.53	1.49	2.72	4.14	2.27	1.39	1.35	1.62
15	19.25	28.03	35.59	50.61	55.30	62.50	/	1.55	1.88	3.45	1.95	1.65	1.23	/
16	18.82	27.94	37.43	43.15	50.82	59.66	/	1.65	2.43	2.06	2.03	0.74	1.29	/
17	18.90	27.69	37.70	47.95	51.06	58.28	65.89	1.52	1.94	2.07	1.14	1.11	1.29	1.29
18	19.21	29.41	36.29	49.75	62.56	67.34	/	1.54	2.67	3.35	2.50	0.98	1.29	/
19	18.96	27.76	37.43	48.75	49.94	65.12	/	1.36	2.25	1.72	2.85	1.31	2.11	/
20	18.88	28.49	36.54	43.67	49.30	55.92	/	1.43	2.54	1.95	1.73	2.42	1.29	/
21	18.94	28.40	36.83	42.41	50.94	57.07	/	1.52	2.44	2.94	1.50	2.06	1.18	/
22	18.77	27.57	37.70	42.10	55.01	58.15	65.29	1.84	1.75	2.53	3.32	1.77	0.87	0.95
23	18.87	28.15	36.44	48.98	50.32	58.94	/	1.18	2.45	2.26	1.42	2.86	1.82	/
24	19.25	29.24	45.04	54.33	59.52	/	/	1.39	2.33	2.09	1.73	2.57	/	/
25	19.03	28.16	36.71	43.67	53.46	62.90	67.95	1.48	2.26	2.42	2.30	2.19	1.06	1.49
26	18.55	28.44	36.41	52.46	63.30	61.50	/	1.45	1.77	2.75	1.09	1.09	1.70	/
27	18.67	28.47	36.64	41.16	49.53	59.72	/	1.36	2.96	3.24	1.30	1.37	1.26	/
28	18.44	28.65	36.12	42.73	55.28	63.97	67.50	2.15	2.35	10.36	2.15	1.34	1.20	0.90
29	18.51	28.72	35.55	43.70	49.35	58.64	65.08	1.65	2.71	2.85	2.00	2.29	1.35	1.35
30	18.84	28.76	36.02	42.85	47.44	60.80	65.93	1.21	2.56	5.09	2.59	1.83	1.50	1.20
31	18.87	27.76	35.94	42.37	53.52	60.28	/	1.67	1.87	2.25	2.30	1.49	0.98	/
32	18.91	28.08	38.11	49.54	49.73	56.05	66.04	1.44	3.61	1.97	2.99	1.43	1.29	1.15
33	18.82	28.69	35.98	45.99	49.31	54.30	65.11	1.56	2.30	2.61	1.19	1.44	1.57	1.15
34	19.07	30.25	36.17	45.58	53.00	59.17	/	1.46	3.87	2.60	2.10	1.69	3.36	/
35	19.16	28.68	36.12	43.87	52.03	56.85	66.23	1.50	2.49	1.72	2.10	1.48	1.41	0.82
36	18.98	28.43	36.09	51.14	49.75	57.38	64.29	1.59	2.73	2.07	1.20	1.78	1.26	0.95
37	19.14	27.99	37.03	42.35	47.31	66.58	/	1.59	3.01	3.65	2.19	4.75	1.63	/
38	18.97	28.52	45.06	57.95	/	/	/	1.49	2.46	2.09	1.98	/	/	/
39	19.05	28.02	38.65	42.52	52.84	58.95	65.00	1.45	2.26	2.53	1.83	1.61	1.52	0.74
40	19.15	28.00	36.75	44.76	48.88	58.18	63.16	1.52	1.80	1.58	1.72	1.92	1.41	2.22
41	18.91	28.24	34.65	43.84	54.91	58.19	63.44	1.43	2.45	3.90	1.23	1.38	0.82	1.70
42	18.88	28.07	37.71	44.30	48.94	56.54	62.45	1.33	1.98	2.25	1.01	2.79	2.60	1.27
43	18.98	28.28	36.46	42.37	52.57	56.24	66.00	1.48	2.04	1.94	8.40	1.89	1.23	0.67
44	18.94	28.70	41.93	43.12	55.68	59.41	66.62	1.51	2.38	3.63	1.27	1.04	1.41	1.75
45	19.52	28.41	40.21	43.44	50.87	56.72	/	2.01	2.39	2.16	2.05	1.40	3.71	/
46	19.00	28.10	34.85	48.58	51.84	58.01	64.25	1.50	2.02	4.31	1.45	2.04	2.11	1.35
47	18.85	28.26	36.45	43.11	50.64	58.40	67.50	1.55	2.42	2.25	3.65	1.98	1.18	1.06
48	19.19	28.55	35.24	42.28	47.83	54.78	62.15	1.43	2.21	2.97	2.96	3.84	0.87	0.98
49	19.13	28.31	36.66	42.45	49.28	55.32	62.41	1.49	2.64	5.42	2.12	1.16	2.40	0.98
50	18.91	27.69	37.55	42.37	53.45	57.25	/	1.37	1.87	1.59	1.43	2.27	1.49	/
51	18.82	30.44	36.51	43.58	47.92	57.19	/	1.39	3.69	2.83	1.91	1.41	1.67	/
52	18.84	27.46	36.10	42.12	49.76	59.35	/	1.50	2.07	1.48	3.87	2.56	1.06	/
53	19.02	27.92	36.73	43.40	50.12	56.08	64.11	1.55	2.28	1.92	1.66	2.19	1.93	0.75
54	18.92	28.87	43.45	50.41	55.55	63.00	/	1.64	2.80	2.65	1.30	1.58	0.97	/
55	18.97	28.46	39.28	45.73	50.13	61.89	67.23	1.42	2.05	1.96	1.69	1.52	1.29	0.82
56	19.04	28.63	37.35	44.51	50.07	55.82	/	1.39	2.36	4.71	1.35	1.28	1.86	/
57	19.03	28.28	41.54	46.75	50.81	60.37	/	1.44	2.21	1.51	1.27	1.97	2.01	/
58	18.77	27.89	33.74	43.08	50.33	56.61	65.50	1.56	2.23	5.18	4.95	3.40	1.61	0.95
59	18.78	28.79	35.00	42.31	48.50	58.79	64.50	1.33	2.68	5.23	1.26	1.40	2.32	1.04
60	19.03	28.58	35.24	42.65	53.52	56.16	66.85	1.61	2.51	4.53	1.79	1.61	0.80	1.11
61	19.15	27.33	37.64	43.01	49.54	58.10	63.37	1.42	1.65	1.74	2.26	3.79	0.93	1.53
62	18.99	27.65	36.49	43.89	48.08	56.20	/	1.52	2.50	1.80	1.16	3.14	1.68	/
63	19.39	27.99	35.58	45.69	58.04	63.14	/	1.25	2.15	4.28	1.38	1.20	0.84	/
64	18.90	28.59	38.42	42.79	49.63	58.03	65.00	1.42	2.56	4.18	3.53	1.17	0.94	0.85
65	18.61	28.37	35.76	47.13	48.13	55.19	/	1.21	1.95	4.56	1.14	1.25	1.16	/
66	19.06	28.18	38.15	43.98	50.04	52.27	/	1.67	1.99	1.97	1.40	2.23	3.87	/
67	18.83	27.90	36.59	48.73	50.13	58.89	/	1.50	2.90	3.47	1.49	1.58	1.29	/
68	19.13	28.51	36.65	51.27	64.90	/	/	1.70	2.21	4.16	2.03	1.00	/	/
69	18.86	28.75	36.45	46.51	53.28	57.13	66.14	1.40	2.24	1.85	1.61	2.57	1.36	0.84
70	18.92	28.10	34.04	42.61	49.82	56.58	/	1.62	1.91	4.89	2.21	1.95	2.47	/
71	18.90	27.90	36.99	43.75	49.49	59.18	/	1.50	2.27	1.85	1.07	1.03	1.24	/
72	19.10	27.91	33.31	46.68	52.93	59.24	/	1.75	1.97	6.46	1.47	1.33	1.18	/
73	19.06	28.14	36.18	44.01	49.76	65.21	/	1.62	2.24	4.65	2.99	1.37	1.01	/
74	18.85	28.60	34.41	44.75	48.45	56.21	64.92	1.30	2.45	4.37	3.06	2.24	1.31	1.64
75	19.36	27.95	42.82	45.58	53.41	60.50	64.25	1.57	1.91	2.15	1.30	1.25	1.29	1.35
76	19.10	28.28	35.55	40.96	49.64	58.50	67.00	1.48	2.08	3.89	3.51	3.82	1.04	0.56
77	19.10	28.64	37.64	42.16	49.25	58.50	65.21	1.47	2.96	1.84	4.28	1.04	1.25	2.11
78	18.90	28.19	36.41	43.78	50.10	58.36	/	1.44	2.32	2.16	3.60	1.71	1.20	/
79	18.86	30.09	37.48	41.20	48.85	56.70	66.00	1.63	4.83	3.81	1.35	1.41	1.38	0.85
80	19.17	27.24	36.59	43.97	50.89	56.68	65.00	1.56	1.54	4.46	1.85	1.84	1.79	0.85
81	18.52	29.83	35.57	49.71	54.76	58.78	63.82	1.32	3.45	2.88	2.21	2.08	1.44	1.13
82	18.92	28.64	36.61	44.65	49.44	57.22	66.11	1.44	2.38	1.75	1.59	1.31	2.69	1.70
83	18.72	28.70	37.97	43.94	51.07	56.24	64.69	1.39	2.38	2.01	2.33	1.99	1.38	0.90
84	19.13	27.77	37.84	44.61	50.11	57.77	/	1.61	1.74	1.64	1.44	2.29	1.73	/
85	19.00	28.39	39.53	43.04	48.86	57.30	/	1.44	2.47	1.63	1.94	1.22	1.33	/
86	18.07	28.70	37.21	43.89	48.69	55.08	/	1.06	2.47	1.54	1.38	2.04	1.24	/
87	18.82	28.38	37.58	44.17	49.72	61.42	65.29	1.46	2.20	1.80	4.45	2.62	1.77	1.07
88	19.05	27.77	38.15	43.29	52.26	58.95	64.98	1.44	2.06	5.44	2.31	1.08	1.54	1.06
89	18.90	28.97	36.74	44.24	50.28	56.28	67.91	1.44	1.68	1.66	1.77	1.94	3.43	1.86
90	18.79	28.82	37.41	42.66	49.82	58.62	64.14	1.37	2.93	2.58	1.78	1.32	1.26	0.84
91	18.89	28.14	45.87	53.40	56.57	67.00	/	1.65	1.93	6.27	1.24	1.35	1.11	/
92	19.41	27.65	36.86	58.29	48.60	57.93	/	1.29	1.91	2.43	15.82	1.45	2.39	/
93	18.52	28.70	43.73	50.80	56.46	64.12	/	1.19	2.68	6.08	1.21	2.57	1.01	/
94	19.10	28.00	43.74	51.69	57.99	/	/	1.52	2.19	3.81	1.72	1.11	/	/
95	18.86	28.85	37.03	42.71	52.99	62.01	/	1.35	2.49	2.85	3.32	4.08	1.26	/
96	19.36	28.30	36.51	44.63	52.79	56.30	/	1.20	2.26	3.72	2.42	1.99	1.64	/
97	19.17	28.01	36.02	45.83	50.79	55.45	63.97	1.59	2.32	3.50	1.85	1.86	4.50	1.20
98	18.67	27.80	35.34	41.38	50.91	58.11	62.64	1.24	2.20	2.11	3.81	1.18	1.13	1.36
99	19.14	28.64	37.77	43.74	49.04	61.21	64.09	1.56	2.91	3.75	1.56	1.70	1.01	1.06
100	19.07	28.09	35.52	44.93	53.64	56.70	64.98	1.61	2.02	3.58	1.86	2.01	1.63	1.06

Appendix Table B.10c Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 1000 length measurements using the two partitions for grouping the European hake data.

Sample size = 1000 length measurements														
% Bias														
Birgè and Rozenholc algorithm														
	mean 1	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*mean 7*	*SD 1*	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*	*SD 7*
1	-1.06	0.64	0.12	1.66	6.49	/	/	-0.29	15.29	-0.55	3.39	-16.74	/	/
2	-1.14	0.15	-0.03	2.26	/	/	/	0.14	0.97	5.52	10.39	/	/	/
3	-1.07	-0.63	0.55	4.68	/	/	/	-0.07	1.67	9.94	-3.27	/	/	/
4	-0.73	-0.03	0.22	2.29	2.76	3.79	/	0.78	1.45	3.94	23.87	-1.07	-8.81	/
5	-0.98	-0.45	0.73	6.55	/	/	/	0.20	7.90	0.36	-13.05	/	/	/
6	-0.98	0.07	-0.07	-0.19	4.14	/	/	0.07	1.05	14.47	5.11	10.40	/	/
7	-0.45	-0.96	0.47	5.19	/	/	/	-0.05	2.40	2.90	16.38	/	/	/
8	11.52	-2.09	0.34	3.74	/	/	/	2.77	10.22	27.95	8.96	/	/	/
9	-1.02	-3.94	1.07	/	/	/	/	0.15	7.81	-1.57	/	/	/	/
10	-1.08	-0.96	0.69	5.87	/	/	/	0.01	14.64	-0.40	3.69	/	/	/
11	-1.20	-0.76	0.76	5.64	/	/	/	0.17	5.27	0.29	7.65	/	/	/
12	-0.86	-0.79	0.47	5.11	/	/	/	-0.02	4.07	0.02	-2.97	/	/	/
13	-0.62	-1.04	0.21	2.23	6.65	/	/	-0.17	0.41	0.39	0.47	-13.73	/	/
14	-0.67	0.11	0.23	4.32	6.93	/	/	0.36	0.67	9.11	-3.67	1.78	/	/
15	12.16	-0.77	0.67	/	/	/	/	4.83	21.10	12.79	/	/	/	/
16	-1.16	-1.29	0.46	5.03	/	/	/	0.20	10.03	0.71	-2.93	/	/	/
17	-1.16	-0.11	0.19	3.86	/	/	/	0.20	3.14	8.41	35.37	/	/	/
18	-0.81	-0.86	0.49	3.27	/	/	/	0.20	1.87	-0.22	-6.14	/	/	/
19	-0.96	0.12	0.18	2.38	6.59	/	/	0.33	0.25	10.72	70.69	14.85	/	/
20	-1.22	-0.05	0.29	2.05	5.57	/	/	0.30	3.16	7.01	6.22	-3.62	/	/
21	-1.02	-1.11	0.24	2.56	7.04	/	/	-0.05	1.30	-0.39	-7.51	-17.86	/	/
22	-0.98	-0.04	0.20	4.31	6.64	/	/	0.57	2.91	11.25	377.99	2.90	/	/
23	-1.02	-0.91	0.56	4.98	/	/	/	-0.09	7.03	4.50	0.38	/	/	/
24	10.41	-2.99	0.86	/	/	/	/	4.61	17.89	10.08	/	/	/	/
25	-0.88	0.13	0.21	1.92	2.25	3.76	/	0.33	1.66	6.55	45.48	11.91	-10.47	/
26	-1.67	-0.04	0.38	5.43	/	/	/	0.18	2.73	12.47	-1.92	/	/	/
27	-1.11	-0.85	0.43	3.66	7.57	/	/	0.06	2.63	3.80	-5.94	-1.45	/	/
28	-0.58	0.01	0.25	2.41	6.14	6.34	/	0.09	0.09	5.53	-6.58	-10.54	-17.61	/
29	-0.98	0.10	0.29	2.21	4.35	/	/	-0.04	-0.38	-0.92	-0.07	-10.94	/	/
30	-0.77	0.01	0.14	3.59	6.05	/	/	-0.24	0.99	-1.45	-9.01	-13.69	/	/
31	-0.87	-0.19	0.15	1.31	3.38	/	/	1.28	3.86	3.76	6.75	32.12	/	/
32	-0.93	-1.24	0.31	3.70	/	/	/	0.05	5.94	-1.54	-4.70	/	/	/
33	-1.00	-0.77	0.44	4.56	/	/	/	0.01	1.42	6.58	10.96	/	/	/
34	-0.47	-0.65	0.63	4.83	/	/	/	0.28	9.03	1.33	-9.01	/	/	/
35	-0.78	-0.80	0.22	3.03	7.35	/	/	-0.02	-0.12	-0.27	-0.52	-6.55	/	/
36	-1.00	-0.65	0.41	4.59	/	/	/	0.24	3.71	13.13	0.70	/	/	/
37	-0.76	-1.01	0.50	3.85	/	/	/	0.46	2.84	4.28	-11.03	/	/	/
38	-1.21	0.55	0.47	5.75	/	/	/	0.01	15.22	3.48	-9.53	/	/	/
39	-0.87	-4.01	1.06	/	/	/	/	0.10	0.01	0.00	/	/	/	/
40	-1.28	-0.68	0.48	5.66	/	/	/	0.06	10.27	2.13	11.72	/	/	/
41	-1.40	-3.50	/	/	/	/	/	0.06	10.24	/	/	/	/	/
42	-1.31	-0.94	0.65	5.27	/	/	/	-0.04	1.79	8.92	3.77	/	/	/
43	-0.67	-0.86	0.25	2.20	5.19	/	/	0.08	2.62	0.12	-5.55	-12.03	/	/
44	-1.18	0.01	-0.10	1.64	2.40	2.56	/	0.23	1.47	20.74	33.43	6.45	22.33	/
45	-1.38	-0.77	0.59	6.21	/	/	/	0.10	4.06	6.81	-5.52	/	/	/
46	-0.97	-0.77	0.24	4.76	/	/	/	0.17	1.82	0.94	5.16	/	/	/
47	-0.87	-0.90	0.61	4.13	/	/	/	0.21	1.40	-1.54	-7.90	/	/	/
48	-0.61	-0.73	0.24	2.75	8.61	/	/	0.09	3.58	1.62	22.44	-10.83	/	/
49	-1.39	0.14	0.09	1.25	6.47	/	/	0.14	1.84	15.91	43.21	2.26	/	/
50	-1.02	-0.05	0.53	5.85	/	/	/	-0.07	7.99	18.88	-6.18	/	/	/
51	-0.98	-0.87	0.52	4.41	/	/	/	0.11	2.57	11.79	-3.18	/	/	/
52	-0.78	-1.01	0.31	3.50	/	/	/	0.17	6.61	27.86	29.82	/	/	/
53	8.39	-1.77	0.57	3.48	/	/	/	1.99	9.04	14.54	20.49	/	/	/
54	-0.97	-3.45	0.92	/	/	/	/	0.37	5.54	6.57	/	/	/	/
55	-1.19	-2.62	0.50	5.31	/	/	/	-0.08	8.06	13.69	-5.54	/	/	/
56	-1.20	-3.56	0.95	/	/	/	/	-0.08	4.23	5.85	/	/	/	/
57	-1.02	0.08	0.27	3.07	6.01	/	/	-0.01	-0.79	7.49	3.27	-6.06	/	/
58	-1.00	0.00	0.28	2.30	6.32	/	/	0.10	-0.29	3.76	2.63	-14.51	/	/
59	-1.18	-0.11	0.42	6.25	/	/	/	0.02	17.81	3.78	3.21	/	/	/
60	-1.32	-0.87	0.50	5.45	/	/	/	0.08	5.95	2.11	-6.37	/	/	/
61	-0.58	-1.06	0.54	5.22	/	/	/	0.17	7.88	0.18	-6.66	/	/	/
62	-0.97	-0.88	0.48	5.50	/	/	/	0.40	4.50	5.92	-9.20	/	/	/
63	-1.00	-0.82	0.12	4.37	/	/	/	-0.03	3.04	18.23	8.51	/	/	/
64	-1.08	0.06	0.43	2.24	6.78	/	/	0.61	0.85	19.35	35.06	-1.46	/	/
65	-1.08	-0.93	0.53	4.56	/	/	/	0.16	3.19	11.48	2.48	/	/	/
66	-1.24	-2.09	0.53	5.69	/	/	/	-0.06	2.07	2.23	-9.45	/	/	/
67	-1.18	-0.67	0.41	5.36	/	/	/	0.07	11.65	0.90	-8.99	/	/	/
68	-0.69	0.03	0.25	1.56	3.51	6.22	/	0.81	1.66	16.92	6.78	18.96	-5.26	/
69	-0.50	0.11	0.14	2.34	6.08	/	/	0.76	1.68	11.89	30.79	1.54	/	/
70	-0.93	-0.87	0.15	5.48	/	/	/	0.19	2.43	34.97	8.78	/	/	/
71	-0.52	-2.27	0.76	/	/	/	/	0.29	12.25	-2.64	/	/	/	/
72	-1.06	-0.33	0.58	4.03	/	/	/	0.18	10.05	3.53	4.55	/	/	/
73	12.10	-5.70	/	/	/	/	/	4.08	3.62	/	/	/	/	/
74	-0.99	-0.74	0.85	/	/	/	/	-0.09	2.36	2.29	/	/	/	/
75	8.68	-3.44	0.91	/	/	/	/	2.50	17.38	10.51	/	/	/	/
76	-0.54	0.08	0.21	0.22	3.37	/	/	0.76	0.89	3.67	71.54	3.99	/	/
77	-0.87	-3.35	0.91	6.29	/	/	/	-0.07	4.64	-2.37	-6.03	/	/	/
78	-0.56	-0.06	0.57	3.26	/	/	/	0.21	2.03	1.66	-3.93	/	/	/
79	-1.12	-1.10	0.58	3.61	/	/	/	0.07	6.26	2.41	1.34	/	/	/
80	-1.16	-0.28	0.58	/	/	/	/	0.10	13.92	1.34	/	/	/	/
81	-1.49	0.04	-0.05	1.91	5.26	/	/	0.12	1.82	2.19	28.95	10.68	/	/
82	-1.11	-0.64	0.27	4.91	/	/	/	0.16	1.83	2.06	5.14	/	/	/
83	-0.87	-1.17	0.59	4.03	/	/	/	0.25	2.32	0.55	-2.13	/	/	/
84	-0.65	-0.50	0.43	5.21	/	/	/	0.43	5.07	1.06	-0.04	/	/	/
85	-0.90	-0.73	0.53	4.02	/	/	/	0.14	5.45	0.35	2.48	/	/	/
86	-0.90	-0.93	0.29	3.84	/	/	/	0.12	0.77	8.75	-7.07	/	/	/
87	-0.99	-0.99	0.55	5.59	/	/	/	0.12	3.59	1.25	6.51	/	/	/
88	13.59	/	/	/	/	/	/	9.18	/	/	/	/	/	/
89	-0.60	-0.74	0.50	4.91	/	/	/	-0.05	1.34	15.96	-6.85	/	/	/
90	-1.05	-2.03	0.92	/	/	/	/	0.09	1.79	0.88	/	/	/	/
91	-1.41	-0.92	0.51	/	/	/	/	0.14	6.73	6.91	/	/	/	/
92	10.02	-2.12	0.65	/	/	/	/	2.60	18.85	19.04	/	/	/	/
93	-1.04	-0.85	0.51	3.94	/	/	/	0.21	1.35	-1.90	15.00	/	/	/
94	-0.76	-1.01	0.55	3.91	/	/	/	0.12	3.16	0.57	-3.60	/	/	/
95	-0.75	-0.92	/	/	/	/	/	0.14	4.38	/	/	/	/	/
96	-0.78	-2.02	0.52	6.14	/	/	/	0.04	4.47	-0.07	-8.83	/	/	/
97	-0.83	-0.79	0.59	/	/	/	/	0.47	3.80	-1.09	/	/	/	/
98	11.72	/	/	/	/	/	/	5.57	/	/	/	/	/	/
99	-1.10	-0.36	0.37	6.13	/	/	/	0.14	13.85	21.53	-6.56	/	/	/
100	-1.16	-6.11	/	/	/	/	/	0.18	1.89	/	/	/	/	/

Appendix Table B.10d Estimates and corresponding percentage bias of mean lengths-at-age and standard deviations obtained in the sub-sampling of 1000 length measurements using the two partitions for grouping the European hake data.

	Sample size = 1000 length measurements													
	% Bias													
	2 cm													
	mean 1	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*mean 7*	*SD 1*	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*	*SD 7*
1	-2.71	7.66	-5.85	8.81	28.59	17.13	/	-58.13	97.47	-127.98	-50.33	-64.18	-73.11	/
2	-2.90	5.70	629.58	64.03	28.06	/	/	-46.01	126.28	-83.59	-50.96	-64.73	/	/
3	-1.94	12.06	-27.57	-6.98	20.27	10.53	11.00	-75.49	-70.79	-37.24	85.15	-73.12	-70.14	-69.34
4	-1.49	14.41	453.50	47.58	8.11	15.39	/	122.23	-149.16	63.44	-60.28	-63.04	-67.01	/
5	-1.48	4.94	24.90	3.25	20.72	8.22	/	-39.79	174.91	-35.28	14.02	-57.53	-63.34	/
6	-2.28	-11.64	1.07	4.74	3.52	4.99	6.39	-258.66	292.68	22.66	-35.20	-49.63	-22.24	-72.67
7	-1.61	25.97	39.27	19.77	1.94	9.73	4.28	-194.67	-146.64	43.97	-7.43	-55.48	-55.14	-80.79
8	40.30	-144.17	587.27	55.18	29.89	/	/	104.08	-144.03	317.16	-8.49	-53.86	/	/
9	-2.11	-1.46	-0.20	9.04	5.19	7.01	7.17	151.91	-5.70	2.58	-49.59	-30.44	-48.43	-59.75
10	-2.31	11.69	104.32	7.79	6.11	13.69	/	-141.38	1.01	32.10	6.86	-51.61	-27.22	/
11	-2.82	12.04	72.33	17.02	11.08	5.78	/	-163.68	-152.09	-91.09	-41.04	-39.29	-72.19	/
12	-1.06	-6.72	-40.42	2.71	13.06	8.64	/	92.71	81.63	-46.07	-26.68	-13.07	-73.48	/
13	-2.51	6.39	9.16	1.92	23.42	/	/	-180.84	117.71	36.98	-35.56	-48.76	/	/
14	-1.55	-0.95	4.24	2.52	4.95	9.45	5.70	26.28	144.85	234.87	-18.29	-57.21	-63.34	-61.52
15	-0.71	9.48	-58.89	52.09	19.49	16.45	/	89.65	-115.29	135.38	-29.83	-49.24	-66.57	/
16	-2.93	11.51	60.53	5.52	7.90	11.16	/	192.21	56.59	-66.65	-26.95	-77.14	-64.98	/
17	-2.50	16.60	78.25	35.45	8.50	8.58	6.28	49.00	-95.95	-64.64	-59.15	-65.91	-64.98	-69.46
18	-0.91	-19.10	-13.52	46.72	38.27	25.47	/	79.47	129.84	119.64	-9.92	-69.82	-64.84	/
19	-2.20	15.24	60.30	40.45	5.61	21.33	/	-115.56	-1.56	-116.22	2.43	-59.65	-42.70	/
20	-2.63	-0.04	2.31	8.73	3.96	4.20	/	-44.37	88.76	-82.04	-37.88	-25.42	-64.84	/
21	-2.33	1.94	21.41	0.85	8.21	6.34	/	56.15	58.43	60.58	-45.90	-36.54	-67.92	/
22	-3.19	19.04	77.81	-1.08	18.74	8.35	5.31	395.21	-154.57	1.10	19.54	-45.53	-76.34	-77.39
23	-2.69	7.00	-3.66	41.90	6.61	9.82	/	-310.93	63.30	-37.55	-48.75	-12.11	-50.53	/
24	-0.75	-15.65	555.01	75.31	30.42	/	/	-81.38	24.87	-61.91	-37.79	-21.03	/	/
25	-1.88	6.82	13.95	8.72	14.72	17.20	9.60	12.14	1.70	-14.12	-17.24	-32.66	-71.29	-64.59
26	-4.33	0.95	-6.00	63.60	40.20	14.59	/	-24.67	-150.42	33.74	-60.86	-66.37	-53.84	/
27	-3.73	0.41	9.09	-6.93	4.56	11.27	/	-118.39	221.97	104.38	-53.28	-57.89	-65.89	/
28	-4.90	-3.22	-24.54	2.89	19.43	19.19	8.87	736.04	30.50	1136.05	-22.82	-58.91	-67.36	-78.74
29	-4.53	-4.75	-61.92	8.91	4.09	9.25	4.97	194.48	144.52	47.88	-28.14	-29.69	-63.34	-68.03
30	-2.83	-5.52	-31.33	3.63	-0.86	13.28	6.34	-275.74	97.43	371.81	-6.78	-43.59	-59.19	-71.59
31	-2.70	15.15	-36.49	0.60	14.88	12.31	/	217.34	-117.65	-38.65	-17.29	-54.20	-73.25	/
32	-2.46	8.48	104.47	45.38	5.07	4.44	6.51	-31.56	421.96	-80.35	7.69	-56.06	-64.98	-72.67
33	-2.94	-4.22	-33.77	23.26	3.99	1.17	5.02	100.57	16.11	13.17	-57.27	-55.65	-57.40	-72.67
34	-1.63	-36.59	-21.25	20.66	13.53	10.24	/	-13.87	503.04	12.11	-24.62	-47.90	-8.56	/
35	-1.19	-3.91	-24.91	9.98	11.03	5.93	6.82	33.84	76.26	-116.22	-24.33	-54.54	-61.79	-80.68
36	-2.12	1.27	-26.84	55.36	5.12	6.91	3.69	125.86	150.21	-65.18	-56.66	-45.29	-65.67	-77.39
37	-1.27	10.30	34.25	0.49	-1.18	24.05	/	134.48	235.89	164.31	-21.25	46.14	-55.69	/
38	-2.19	-0.57	556.08	97.88	/	/	/	19.86	64.88	-62.21	-28.84	/	/	/
39	-1.78	9.69	139.92	1.59	13.12	9.84	4.84	-26.76	3.23	0.98	-34.34	-50.49	-58.77	-82.50
40	-1.22	10.15	16.21	15.54	2.88	8.41	1.86	57.13	-139.04	-135.73	-38.09	-41.01	-61.72	-47.46
41	-2.48	5.12	-120.16	9.78	18.48	8.42	2.33	-47.71	62.45	199.94	-55.68	-57.39	-77.80	-59.75
42	-2.63	8.82	78.75	12.66	3.02	5.35	0.72	-153.62	-84.33	-38.71	-63.61	-14.26	-29.30	-69.81
43	-2.12	4.44	-2.68	0.63	12.42	4.79	6.45	11.12	-66.15	-83.43	202.23	-41.83	-66.52	-84.01
44	-2.34	-4.32	352.72	5.31	20.47	10.70	7.45	39.72	39.08	161.09	-54.35	-68.10	-61.77	-58.56
45	0.65	1.56	241.05	7.33	8.01	5.68	/	584.54	42.03	-51.64	-26.18	-56.95	0.78	/
46	-2.03	8.06	-107.13	39.42	10.53	8.09	3.64	33.84	-70.15	259.50	-47.82	-37.32	-42.72	-68.03
47	-2.78	4.69	-3.08	5.23	7.41	8.81	8.87	91.41	52.59	-38.80	31.34	-39.18	-67.92	-74.96
48	-1.06	-1.19	-81.69	0.06	0.15	2.07	0.24	-41.89	-13.97	65.34	6.31	18.27	-76.26	-76.76
49	-1.35	3.70	10.38	1.15	3.91	3.08	0.66	23.03	121.22	419.63	-23.84	-64.25	-34.76	-76.76
50	-2.49	16.62	68.01	0.65	14.71	6.67	/	-104.93	-117.98	-134.78	-48.44	-30.17	-59.40	/
51	-2.96	-40.42	0.78	8.20	0.38	6.56	/	-90.70	449.73	45.56	-31.41	-56.56	-54.75	/
52	-2.83	21.29	-25.99	-0.93	5.16	10.58	/	34.81	-56.10	-151.01	39.24	-21.13	-71.06	/
53	-1.89	11.77	14.70	7.08	6.07	4.50	3.41	89.88	8.23	-87.04	-40.37	-32.58	-47.66	-82.30
54	-2.41	-7.83	451.53	50.82	20.14	17.38	/	187.48	170.56	19.35	-53.07	-51.30	-73.66	/
55	-2.15	0.55	180.48	21.59	6.11	15.32	8.44	-58.67	-61.15	-80.96	-39.32	-53.36	-64.98	-80.68
56	-1.78	-2.91	55.24	14.01	5.96	4.00	/	-87.73	33.48	316.57	-51.38	-60.66	-49.34	/
57	-1.86	4.40	327.32	28.00	7.88	12.48	/	-28.42	-11.04	-146.09	-54.17	-39.44	-45.43	/
58	-3.21	12.37	-179.18	5.05	6.62	5.48	5.65	91.69	-5.34	385.08	77.94	4.48	-56.15	-77.39
59	-3.15	-6.18	-97.68	0.22	1.90	9.55	4.03	-150.52	133.91	392.40	-54.55	-56.88	-36.84	-75.24
60	-1.86	-1.82	-82.05	2.38	14.87	4.64	7.83	147.27	81.98	290.41	-35.61	-50.46	-78.36	-73.69
61	-1.25	24.13	74.04	4.62	4.58	8.25	2.21	-55.68	-185.48	-112.41	-18.83	16.65	-74.67	-63.74
62	-2.04	17.47	-0.91	10.11	0.81	4.72	/	50.72	78.94	-104.32	-58.35	-3.28	-54.25	/
63	0.02	10.33	-59.49	21.38	26.59	17.65	/	-238.93	-30.43	254.36	-50.25	-63.04	-77.25	/
64	-2.55	-2.08	124.83	3.22	4.82	8.12	4.84	-49.81	97.89	240.86	26.93	-64.07	-74.45	-79.87
65	-4.05	2.52	-48.39	30.35	0.93	2.83	/	-275.24	-93.27	295.90	-59.15	-61.52	-68.59	/
66	-1.68	6.53	107.07	10.68	5.87	-2.61	/	214.97	-82.24	-80.04	-49.54	-31.29	5.17	/
67	-2.90	12.21	5.56	40.31	6.11	9.73	/	27.33	203.36	137.97	-46.56	-51.47	-64.98	/
68	-1.35	-0.49	9.65	56.19	44.33	/	/	251.49	-11.11	238.03	-27.02	-69.34	/	/
69	-2.74	-5.37	-3.44	26.46	14.25	6.44	6.68	-79.63	-2.16	-97.60	-42.01	-20.94	-62.93	-80.16
70	-2.41	8.19	-159.56	2.09	5.30	5.42	/	157.67	-106.77	343.73	-20.53	-40.04	-32.99	/
71	-2.53	12.17	31.67	9.26	4.45	10.26	/	32.76	5.44	-96.71	-61.44	-68.24	-66.37	/
72	-1.49	12.00	-207.60	27.55	13.36	10.39	/	304.84	-86.36	570.89	-47.07	-59.01	-67.83	/
73	-1.71	7.16	-20.58	10.83	5.15	21.50	/	162.05	-2.48	307.79	7.58	-57.80	-72.56	/
74	-2.80	-2.32	-136.12	15.49	1.76	4.73	4.71	-185.50	61.62	268.28	10.14	-31.07	-64.37	-61.17
75	-0.17	11.21	410.45	20.69	14.60	12.73	3.64	112.53	-105.38	-53.08	-53.07	-61.60	-64.98	-68.03
76	-1.52	4.38	-61.51	-8.18	4.83	9.00	8.06	7.51	-53.98	198.36	26.33	17.47	-71.73	-86.79
77	-1.51	-3.12	74.15	-0.69	3.83	9.00	5.18	-3.11	219.97	-98.22	53.85	-68.06	-66.04	-49.93
78	-2.52	6.22	-5.53	9.45	6.03	8.74	/	-30.78	22.57	-52.45	29.61	-47.42	-67.36	/
79	-2.72	-33.30	63.61	-6.71	2.79	5.65	6.45	170.79	804.07	186.12	-51.47	-56.55	-62.49	-79.87
80	-1.15	25.88	6.02	10.64	8.08	5.62	4.84	101.31	-221.79	281.33	-33.29	-43.45	-51.42	-79.87
81	-4.50	-27.82	-60.67	46.45	18.09	9.52	2.93	-163.81	372.27	51.91	-20.64	-36.05	-60.88	-73.24
82	-2.43	-3.07	6.91	14.84	4.32	6.61	6.63	-32.58	40.64	-110.90	-42.77	-59.65	-26.91	-59.75
83	-3.47	-4.28	95.66	10.44	8.54	4.79	4.33	-80.79	41.87	-74.55	-16.15	-38.89	-62.46	-78.74
84	-1.32	14.86	86.98	14.61	6.05	7.64	/	153.49	-160.27	-127.78	-48.22	-29.69	-53.10	/
85	-2.04	2.05	196.67	4.83	2.82	6.77	/	-34.51	68.94	-129.61	-30.35	-62.37	-63.80	/
86	-6.80	-4.45	45.87	10.11	2.39	2.63	/	-444.70	68.43	-142.60	-50.50	-37.35	-66.29	/
87	-2.94	2.24	70.24	11.86	5.05	14.44	5.31	-14.38	-14.51	-103.86	60.23	-19.41	-52.00	-74.67
88	-1.76	14.95	107.48	6.38	11.62	9.85	4.81	-30.38	-60.27	422.18	-17.07	-66.65	-58.25	-74.96
89	-2.54	-9.99	15.45	12.28	6.50	4.86	9.53	-33.11	-177.57	-124.75	-36.50	-40.44	-6.85	-55.82
90	-3.11	-6.78	59.13	2.46	5.30	9.22	3.45	-102.96	212.10	8.30	-35.81	-59.47	-65.67	-80.16
91	-2.56	7.31	609.14	69.49	22.78	24.84	/	196.57	-99.36	542.95	-55.35	-58.48	-69.82	/
92	0.10	17.50	23.68	100.05	2.14	7.95	/	-194.89	-107.19	-13.04	469.21	-55.40	-35.05	/
93	-4.51	-4.34	469.88	53.24	22.48	19.48	/	-298.50	134.62	515.19	-56.59	-20.94	-72.45	/
94	-1.50	10.19	470.33	58.83	26.45	/	/	49.23	-17.73	187.42	-38.21	-65.70	/	/
95	-2.74	-7.43	34.74	2.76	13.51	15.54	/	-133.36	73.80	47.95	19.53	25.50	-65.67	/
96	-0.18	3.94	0.75	14.74	13.00	4.90	/	-287.46	2.13	173.82	-13.08	-38.85	-55.38	/
97	-1.14	10.02	-31.51	22.26	7.82	3.31	3.18	126.21	22.06	142.31	-33.45	-42.87	22.22	-71.54
98	-3.73	14.28	-75.15	-5.54	8.13	8.27	1.04	-242.77	-14.36	-59.84	37.02	-63.68	-69.32	-67.73
99	-1.27	-3.17	82.39	9.19	3.28	14.04	3.37	98.83	205.78	177.80	-43.76	-47.73	-72.56	-74.96
100	-1.63	8.24	-63.54	16.63	15.19	5.65	4.81	153.21	-71.96	153.70	-33.14	-38.13	-55.79	-74.96

Appendix Table B.11a Estimates and corresponding percentage bias of the demographic parameters computed by means of the ELEFAN I method and the EM algorithm in the sub-sampling of 1000 length measurements extracted from the Red mullet hypothetical population.

Sample size = 1000 length measurements																	
Estimates																	
ELEFAN I method																	
	L_∞ (cm)	*k (year-1)*	*t_0 (year)*	*mean 1 (cm)*	*mean 2 (cm)*	*mean 3 (cm)*	*mean 4 (cm)*	*mean 5 (cm)*	*mean 6 (cm)*	*mean 7 (cm)*	*SD 1 (cm)*	*SD 2 (cm)*	*SD 3 (cm)*	*SD 4 (cm)*	*SD 5 (cm)*	*SD 6 (cm)*	*SD 7 (cm)*
1	20.00	0.20	-3.00	7.34	11.48	12.66	15.03	17.99	/	/	1.08	1.82	0.33	0.32	0.10	/	/
2	22.60	0.26	-0.96	7.51	12.26	15.22	/	/	/	/	1.47	2.13	0.33	/	/	/	/
3	21.00	0.20	-2.35	7.86	11.56	14.51	15.99	/	/	/	0.32	2.20	0.50	0.57	/	/	/
4	20.10	0.30	-1.31	7.93	11.93	15.93	/	/	/	/	0.60	1.93	0.40	/	/	/	/
5	21.10	0.30	-0.91	7.61	12.50	15.21	/	/	/	/	1.50	2.22	0.25	/	/	/	/
6	20.50	0.30	-0.93	7.58	12.16	14.78	/	/	/	/	1.07	2.50	0.38	/	/	/	/
7	21.50	0.20	-2.44	7.51	11.86	14.96	16.83	/	/	/	0.73	2.22	0.38	0.32	/	/	/
8	20.30	0.22	-2.85	7.21	11.86	15.85	17.18	/	/	/	0.82	2.20	0.45	0.15	/	/	/
9	20.90	0.22	-2.40	7.28	12.23	15.06	17.18	/	/	/	0.50	2.13	0.37	0.45	/	/	/
10	22.10	0.28	-0.96	7.78	12.55	15.53	/	/	/	/	1.00	2.00	0.52	/	/	/	/
11	19.70	0.20	-3.75	7.52	12.22	14.58	16.46	17.40	/	/	1.27	1.88	0.18	0.15	0.28	/	/
12	20.60	0.22	-1.15	7.69	11.41	12.47	13.53	15.12	16.18	/	0.68	1.75	0.28	0.20	0.42	3.66	/
13	20.00	0.20	-2.76	7.64	11.93	12.65	15.51	16.94	/	/	0.60	2.13	0.77	0.30	0.37	/	/
14	21.80	0.20	-2.36	7.47	12.02	14.62	17.22	/	/	/	0.43	2.13	0.27	0.13	/	/	/
15	21.00	0.22	-2.47	7.70	12.32	15.78	16.93	/	/	/	1.13	2.22	0.28	0.28	/	/	/
16	19.40	0.34	-1.11	7.51	12.43	15.70	/	/	/	/	0.67	2.43	0.27	/	/	/	/
17	19.70	0.32	-1.10	7.53	12.15	15.45	/	/	/	/	0.78	1.78	0.53	/	/	/	/
18	19.60	0.24	-2.50	7.54	12.08	15.11	16.63	/	/	/	0.98	2.03	0.45	0.32	/	/	/
19	20.00	0.20	-3.18	7.97	12.63	13.80	15.55	17.30	/	/	0.70	1.85	0.22	0.38	0.15	/	/
20	20.40	0.32	-0.95	7.26	12.59	15.55	0.40	/	/	/	1.12	2.18	/	/	/	/	/
21	20.50	0.24	-1.91	7.83	12.65	14.45	16.26	/	/	/	0.87	2.07	0.50	0.53	/	/	/
22	20.10	0.20	-1.87	7.47	11.13	12.17	14.26	15.30	/	/	0.77	1.63	0.68	0.22	0.25	/	/
23	20.60	0.28	-1.25	7.84	11.70	15.57	/	/	/	/	1.02	1.95	0.32	/	/	/	/
24	19.40	0.32	-1.13	7.55	11.98	15.30	/	/	/	/	1.12	2.02	0.35	/	/	/	/
25	20.90	0.22	-2.15	7.40	12.25	14.68	16.50	/	/	/	1.18	1.97	0.32	0.28	/	/	/
26	18.80	0.20	-3.39	7.88	12.15	15.20	/	/	/	/	1.15	1.93	0.50	/	/	/	/
27	20.00	0.24	-2.12	7.64	12.33	14.68	16.24	/	/	/	0.12	2.20	0.38	0.50	/	/	/
28	21.30	0.20	-2.46	7.38	11.75	15.02	16.65	/	/	/	1.17	1.90	0.25	0.08	/	/	/
29	21.30	0.20	-1.86	7.57	11.74	12.43	15.91	/	/	/	1.12	2.05	0.85	0.37	/	/	/
30	21.00	0.20	-1.96	7.62	11.88	13.30	14.71	16.13	/	/	1.33	1.78	0.30	0.30	0.27	/	/
31	20.40	0.30	-1.07	7.50	12.11	15.41	/	/	/	/	1.20	2.00	0.35	/	/	/	/
32	19.80	0.34	-1.00	7.34	12.67	15.72	/	/	/	/	0.73	2.02	0.55	/	/	/	/
33	20.80	0.28	-1.13	7.66	11.83	15.31	/	/	/	/	0.30	1.98	0.47	/	/	/	/
34	21.20	0.22	-2.11	7.40	12.44	15.24	16.36	/	/	/	0.93	2.07	0.28	0.30	/	/	/
35	22.70	0.26	-0.91	7.61	12.30	14.97	/	/	/	/	1.28	2.05	0.33	/	/	/	/
36	21.10	0.28	-1.20	7.49	12.00	15.95	/	/	/	/	0.90	2.12	0.27	/	/	/	/
37	20.60	0.28	-1.29	7.61	11.72	15.84	/	/	/	/	0.23	2.15	0.68	/	/	/	/
38	22.10	0.26	-1.08	7.67	11.98	15.43	/	/	/	/	0.17	2.08	0.33	/	/	/	/
39	21.40	0.22	-1.18	7.32	11.36	12.51	14.82	/	/	/	0.95	1.78	0.18	0.32	/	/	/
40	20.30	0.26	-0.57	7.71	11.28	12.47	13.66	15.45	16.04	/	0.80	1.77	0.37	0.32	0.43	3.81	/
41	20.30	0.24	-1.84	7.41	12.55	14.49	15.77	/	/	/	1.03	2.15	0.45	0.55	/	/	/
42	22.60	0.20	-1.29	7.67	11.97	12.92	14.35	15.79	17.70	/	1.25	2.03	0.33	0.27	0.38	3.48	/
43	18.60	0.24	-1.77	7.10	12.34	0.00	/	/	/	/	0.37	1.85	/	/	/	/	/
44	21.10	0.20	-2.31	7.66	11.61	14.43	16.13	/	/	/	0.83	1.92	0.30	0.42	/	/	/
45	20.00	0.30	-1.22	7.35	11.86	15.73	/	/	/	/	0.65	1.95	0.37	/	/	/	/
46	20.70	0.24	-1.43	7.69	11.65	12.78	16.18	/	/	/	0.83	2.15	0.62	0.38	/	/	/
47	21.90	0.20	-1.96	7.75	12.07	14.22	15.84	/	/	/	1.42	2.20	0.40	0.30	/	/	/
48	19.60	0.20	-3.05	7.90	12.38	14.06	15.18	16.30	/	/	1.00	2.12	0.37	0.42	0.30	/	/
49	21.10	0.20	-2.48	7.54	11.63	15.12	16.29	/	/	/	0.85	1.92	0.23	0.30	/	/	/
50	21.40	0.22	-0.59	7.24	11.40	12.23	13.90	14.73	15.56	16.81	0.90	1.90	0.45	0.22	0.30	3.61	0.05
51	21.00	0.22	-2.06	7.49	12.29	14.69	16.28	/	/	/	0.03	2.32	0.58	0.38	/	/	/
52	19.30	0.24	-2.58	7.50	11.91	15.22	16.32	/	/	/	0.98	2.07	0.35	0.33	/	/	/
53	21.10	0.20	-2.25	7.83	11.63	14.89	15.43	/	/	/	1.27	1.87	0.28	0.55	/	/	/
54	21.00	0.22	-2.25	7.96	12.30	15.01	16.63	/	/	/	1.18	2.13	0.32	0.25	/	/	/
55	19.50	0.24	-1.55	7.44	12.20	0.00	/	/	/	/	1.10	2.15	/	/	/	/	/
56	20.60	0.30	-1.08	7.52	12.23	15.60	/	/	/	/	0.92	2.00	0.60	/	/	/	/
57	19.90	0.32	-1.02	7.34	12.28	15.37	/	/	/	/	0.78	2.10	0.40	/	/	/	/
58	20.80	0.22	-1.77	7.48	11.85	13.79	15.24	16.21	17.18	/	1.60	1.65	0.30	0.23	0.17	3.48	/
59	20.90	0.28	-1.33	7.47	11.88	16.28	/	/	/	/	1.22	2.07	0.18	/	/	/	/
60	20.00	0.20	-2.91	7.77	11.94	14.02	15.41	16.80	/	/	0.78	1.87	0.55	0.32	0.20	/	/
61	19.40	0.34	-1.09	7.62	12.41	15.60	/	/	/	/	1.03	2.37	0.47	/	/	/	/
62	20.00	0.30	-1.30	7.86	11.86	15.86	/	/	/	/	0.75	1.88	0.40	/	/	/	/
63	21.00	0.30	-0.88	7.33	12.48	15.06	/	/	/	/	0.07	1.87	0.40	/	/	/	/
64	19.50	0.24	-1.95	7.67	12.03	13.77	15.51	/	/	/	1.15	1.73	0.27	0.37	/	/	/
65	19.60	0.24	-2.23	7.73	12.09	14.81	15.90	/	/	/	1.10	2.07	0.43	0.40	/	/	/
66	22.80	0.22	-0.81	7.55	11.64	12.66	15.21	15.72	/	/	1.12	1.77	0.32	0.18	0.45	/	/
67	18.50	0.26	-2.39	7.33	11.96	14.61	15.94	/	/	/	0.93	2.37	0.48	0.35	/	/	/
68	20.10	0.22	-2.35	7.51	11.75	14.78	16.00	/	/	/	1.25	2.03	0.28	0.43	/	/	/
69	23.10	0.24	-1.00	7.20	11.85	15.17	/	/	/	/	0.88	2.12	0.47	/	/	/	/
70	20.10	0.20	-2.96	7.36	12.70	14.75	15.57	16.39	/	/	1.23	2.03	0.15	0.13	0.20	/	/
71	19.30	0.24	-2.67	7.70	11.91	14.72	16.83	/	/	/	0.18	2.27	0.38	0.40	/	/	/
72	22.20	0.26	-0.98	7.82	12.27	15.05	16.16	17.28	/	/	1.00	2.13	0.48	0.38	0.27	/	/
73	21.20	0.20	-2.65	7.51	11.66	15.22	16.99	/	/	/	1.62	1.87	0.32	0.32	/	/	/
74	20.60	0.22	-2.09	7.69	12.07	14.57	15.82	/	/	/	0.58	1.85	0.15	0.33	/	/	/
75	19.30	0.20	-2.13	7.15	7.71	12.18	14.41	16.08	/	/	0.68	2.92	0.25	0.37	0.25	/	/
76	20.40	0.20	-2.35	7.28	12.28	12.91	14.78	16.66	/	/	0.93	2.28	0.52	0.48	0.27	/	/
77	19.00	0.20	-3.00	7.79	11.87	13.04	14.79	15.95	/	/	1.25	1.78	0.35	0.40	0.37	/	/
78	22.00	0.20	-1.15	7.40	7.92	12.12	15.79	/	/	/	1.25	2.57	0.57	0.42	/	/	/
79	18.60	0.30	-1.04	7.39	11.79	13.00	14.60	/	/	/	1.00	2.00	0.08	0.22	/	/	/
80	19.90	0.24	-2.14	7.84	12.26	14.79	16.05	/	/	/	0.63	2.12	0.47	0.35	/	/	/
81	23.40	0.26	-0.90	7.49	12.67	15.55	/	/	/	/	0.90	2.10	0.37	/	/	/	/
82	20.00	0.22	-2.21	7.98	11.69	14.48	15.41	/	/	/	0.03	1.98	0.72	0.78	/	/	/
83	20.80	0.22	-1.83	7.80	12.19	13.83	15.48	/	/	/	1.05	2.18	0.35	0.33	/	/	/
84	19.60	0.32	-1.14	7.89	12.07	15.42	/	/	/	/	0.35	1.53	0.60	/	/	/	/
85	21.10	0.22	-2.34	7.77	12.37	15.25	16.97	/	/	/	1.37	2.22	0.48	0.28	/	/	/
86	20.60	0.28	-1.26	7.78	11.71	15.65	/	/	/	/	0.52	1.95	0.60	/	/	/	/
87	19.60	0.20	-3.37	7.88	12.36	14.84	15.84	16.34	/	/	0.52	1.98	0.15	0.38	0.40	/	/
88	21.80	0.22	-1.66	7.67	12.76	14.46	15.59	/	/	/	1.00	1.97	0.33	0.42	/	/	/
89	19.80	0.22	-2.20	7.77	11.95	13.20	14.87	16.54	/	/	1.38	1.73	0.43	0.23	0.12	/	/
90	20.10	0.24	-1.43	7.61	11.80	12.40	15.40	/	/	/	0.75	2.20	0.70	0.32	/	/	/
91	20.10	0.20	-2.21	7.72	11.88	12.71	14.79	15.63	/	/	1.40	1.75	0.28	0.27	0.17	/	/
92	22.30	0.20	-1.95	7.51	12.28	14.32	16.37	/	/	/	1.47	2.15	0.47	0.40	/	/	/
93	18.40	0.20	-3.72	7.34	12.44	15.35	/	/	/	/	0.65	2.18	0.70	/	/	/	/
94	19.10	0.24	-2.09	7.43	11.79	14.22	15.18	/	/	/	0.65	1.85	0.13	0.15	/	/	/
95	21.90	0.20	-1.44	7.18	11.53	12.07	15.33	/	/	/	0.77	1.98	0.85	0.20	/	/	/
96	19.80	0.30	-1.31	7.73	11.74	15.75	/	/	/	/	1.22	1.73	0.33	/	/	/	/
97	19.60	0.32	-1.06	7.96	12.08	15.02	/	/	/	/	0.78	2.07	0.22	/	/	/	/
98	20.90	0.28	-1.17	7.55	11.88	15.59	/	/	/	/	1.05	2.07	0.37	/	/	/	/
99	21.60	0.28	-1.18	7.54	12.26	16.31	/	/	/	/	0.47	1.80	0.43	/	/	/	/
100	21.10	0.20	-1.89	7.75	11.62	12.73	15.50	/	/	/	1.38	1.83	0.63	0.47	/	/	/

Appendix Table B.11b Estimates and corresponding percentage bias of the demographic parameters computed by means of the ELEFAN I method and the EM algorithm in the sub-sampling of 1000 length measurements extracted from the Red mullet hypothetical population.

	Sample size = 1000 length measurements																				
	Estimates																				
				EM algorithm																	
	L_∞ (cm)	k (year-1)	t_0 (year)	mean 1 (cm)	mean 2 (cm)	mean 3 (cm)	mean 4 (cm)	mean 5 (cm)	mean 6 (cm)	mean 7 (cm)	SD 1 (cm)	SD 2 (cm)	SD 3 (cm)	SD 4 (cm)	SD 5 (cm)	SD 6 (cm)	SD 7 (cm)
1	20.75	0.33	-1.45	7.69	11.21	13.72	15.52	16.81	/	/	2.28	1.52	1.69	1.82	14.74	/	/
2	22.60	0.32	-1.41	8.22	12.17	15.03	/	/	/	/	3.41	2.67	3.12	/	/	/	/
3	21.79	0.34	-1.26	7.65	11.74	14.65	16.72	/	/	/	0.65	-0.04	1.82	2.95	/	/	/
4	20.58	0.04	-1.59	7.56	12.04	16.33	/	/	/	/	0.61	0.08	2.56	/	/	/	/
5	21.10	0.41	-1.20	8.23	12.56	15.43	/	/	/	/	2.70	2.68	2.14	/	/	/	/
6	20.50	0.43	-1.09	7.69	12.16	15.08	/	/	/	/	0.99	2.11	1.08	/	/	/	/
7	21.50	0.40	-1.09	7.59	12.17	15.24	17.31	/	/	/	0.72	1.18	0.49	1.07	/	/	/
8	20.30	0.46	-1.01	7.54	12.25	15.22	17.10	/	/	/	0.80	0.04	2.16	0.30	/	/	/
9	21.24	0.42	-1.05	7.51	12.18	15.26	17.30	/	/	/	0.63	0.54	2.32	2.31	/	/	/
10	24.06	0.36	-1.04	7.60	12.63	16.13	/	/	/	/	0.64	0.93	3.04	/	/	/	/
11	19.75	0.44	-1.18	8.01	12.19	14.88	16.61	17.73	/	/	2.51	1.34	2.68	1.78	4.52	/	/
12	20.60	0.23	-2.04	7.82	10.48	12.59	14.26	15.58	16.63	/	0.67	-0.36	0.33	0.57	3.47	0.76	/
13	20.03	0.39	-1.21	7.57	11.60	14.33	16.17	17.42	/	/	0.64	-0.07	1.93	0.95	3.94	/	/
14	21.80	0.37	-1.15	7.52	11.91	14.95	17.06	/	/	/	0.48	2.02	0.40	0.78	/	/	/
15	21.00	0.47	-0.98	7.72	12.67	15.77	17.72	/	/	/	1.20	1.50	0.44	0.88	/	/	/
16	19.39	0.62	-0.79	7.53	13.02	15.97	/	/	/	/	0.67	1.70	0.87	/	/	/	/
17	21.14	0.16	-1.37	7.57	12.16	16.08	/	/	/	/	0.63	0.24	2.91	/	/	/	/
18	19.62	0.48	-1.03	7.60	12.15	14.97	16.73	/	/	/	1.21	0.01	3.09	2.04	/	/	/
19	20.00	0.38	-1.29	7.80	11.68	14.33	16.13	17.36	/	/	0.70	-0.23	0.34	2.21	0.43	/	/
20	20.40	0.51	-0.90	7.54	12.70	15.78	/	/	/	/	1.17	2.15	1.91	/	/	/	/
21	18.67	0.60	-0.87	7.58	12.56	15.31	16.82	/	/	/	0.67	0.30	2.38	3.17	/	/	/
22	20.09	0.26	-1.90	7.93	10.75	12.92	14.58	15.86	/	/	0.72	-0.34	2.85	0.80	0.38	/	/
23	20.61	0.44	-1.13	8.03	12.49	15.37	/	/	/	/	2.86	2.15	2.49	/	/	/	/
24	19.42	0.48	-1.10	7.97	12.34	15.05	/	/	/	/	2.66	2.39	2.74	/	/	/	/
25	20.91	0.41	-1.12	7.66	12.10	15.05	17.02	/	/	/	1.22	1.37	1.11	5.93	/	/	/
26	18.86	0.56	-0.94	7.70	12.49	15.22	/	/	/	/	0.79	3.34	3.58	/	/	/	/
27	20.01	0.44	-1.13	7.85	12.19	14.98	16.77	/	/	/	1.64	1.82	1.19	1.17	/	/	/
28	21.30	0.39	-1.14	7.69	12.11	15.10	17.12	/	/	/	2.46	1.37	1.31	1.66	/	/	/
29	21.30	0.36	-1.22	7.62	11.79	14.68	16.70	/	/	/	1.00	-0.13	2.78	1.62	/	/	/
30	21.01	0.26	-1.88	8.06	10.99	13.26	15.02	16.38	/	/	2.55	1.50	0.64	0.59	3.20	/	/
31	20.42	0.45	-1.10	7.95	12.45	15.32	/	/	/	/	3.07	2.34	2.63	/	/	/	/
32	22.70	0.41	-0.99	7.51	12.59	15.97	/	/	/	/	0.68	1.26	3.12	/	/	/	/
33	20.89	0.08	-1.56	7.57	11.97	16.05	/	/	/	/	0.62	-0.02	2.92	/	/	/	/
34	21.20	0.43	-1.03	7.54	12.28	15.37	17.39	/	/	/	0.97	0.69	0.37	1.11	/	/	/
35	26.30	0.30	-1.14	7.57	12.41	16.00	/	/	/	/	0.61	0.43	3.01	/	/	/	/
36	21.10	0.48	-0.92	7.57	12.76	15.96	/	/	/	/	0.91	2.20	1.84	/	/	/	/
37	20.98	0.05	-1.64	7.61	11.94	16.07	/	/	/	/	0.65	0.09	2.42	/	/	/	/
38	22.10	0.42	-1.01	7.61	12.57	15.83	/	/	/	/	1.37	2.17	1.65	/	/	/	/
39	21.41	0.23	-1.91	7.65	10.49	12.75	14.54	/	/	/	2.35	1.51	0.80	2.98	/	/	/
40	20.31	0.25	-1.89	7.63	10.43	12.61	14.31	15.64	16.67	/	0.64	0.28	0.66	0.79	0.62	4.26	/
41	17.46	0.69	-0.82	7.55	12.49	14.97	16.21	/	/	/	0.65	0.46	2.96	2.95	/	/	/
42	22.64	0.21	-2.07	8.05	10.84	13.10	14.93	16.40	17.60	/	2.31	0.77	0.71	1.04	1.43	5.71	/
43	20.60	0.64	-0.77	7.27	12.65	/	/	/	/	/	0.40	3.02	/	/	/	/	/
44	21.93	0.35	-1.22	7.59	11.80	14.78	16.88	/	/	/	0.66	0.15	1.83	2.83	/	/	/
45	20.80	0.01	-1.71	7.50	11.81	16.07	/	/	/	/	0.55	1.83	3.05	/	/	/	/
46	20.71	0.28	-1.64	7.56	10.74	13.15	14.97	/	/	/	0.78	1.71	1.06	4.42	/	/	/
47	21.90	0.33	-1.35	7.85	11.79	14.62	16.67	/	/	/	2.35	0.73	0.71	1.79	/	/	/
48	19.59	0.36	-1.40	7.83	11.42	13.92	15.65	16.85	/	/	1.29	2.13	0.66	0.79	0.96	/	/
49	22.50	0.34	-1.21	7.57	11.88	14.94	17.12	/	/	/	0.62	-0.09	1.99	3.00	/	/	/
50	21.39	0.17	-3.22	8.92	10.85	12.48	13.85	15.02	16.00	16.84	2.27	-0.25	0.47	0.26	0.33	2.77	0.62
51	21.01	0.34	-1.50	8.44	12.08	14.66	16.50	/	/	/	2.37	2.16	0.78	0.57	/	/	/
52	19.32	0.54	-0.92	7.56	12.46	15.32	16.99	/	/	/	1.58	0.91	1.05	6.75	/	/	/
53	21.63	0.36	-1.20	7.63	11.89	14.86	16.92	/	/	/	0.65	-0.12	2.07	3.28	/	/	/
54	21.01	0.41	-1.17	8.03	12.40	15.30	17.23	/	/	/	2.27	0.93	0.77	3.08	/	/	/
55	19.50	0.59	-0.82	7.49	12.87	/	/	/	/	/	0.48	3.06	/	/	/	/	/
56	19.89	0.12	-1.45	7.61	12.14	16.15	/	/	/	/	0.64	-0.04	2.77	/	/	/	/
57	22.32	0.39	-1.04	7.51	12.33	15.58	/	/	/	/	0.56	1.63	3.16	/	/	/	/
58	20.81	0.28	-1.71	7.98	11.14	13.52	15.32	16.67	/	/	1.81	-0.10	0.41	0.43	1.51	/	/
59	20.91	0.41	-1.18	8.05	12.39	15.26	/	/	/	/	2.80	2.42	2.85	/	/	/	/
60	19.99	0.38	-1.28	7.72	11.62	14.28	16.09	17.33	/	/	0.75	-0.31	2.68	0.75	0.43	/	/
61	19.40	0.58	-0.86	7.58	12.78	15.69	/	/	/	/	0.96	2.30	1.53	/	/	/	/
62	20.90	0.04	-1.61	7.59	12.07	16.38	/	/	/	/	0.65	0.09	2.66	/	/	/	/
63	18.97	0.57	-0.88	7.50	12.49	15.31	/	/	/	/	0.58	1.81	3.54	/	/	/	/
64	19.51	0.39	-1.31	7.86	11.65	14.21	15.93	/	/	/	1.99	1.12	1.18	4.16	/	/	/
65	21.61	0.48	-1.06	7.79	12.27	15.05	16.78	/	/	/	1.94	0.67	0.70	3.54	/	/	/
66	22.81	0.25	-1.58	7.54	10.96	13.61	15.67	17.27	/	/	0.72	1.00	1.57	1.31	7.53	/	/
67	19.49	0.54	-0.98	7.55	12.10	14.75	16.31	/	/	/	0.91	1.59	0.64	0.51	/	/	/
68	21.03	0.39	-1.13	7.54	11.93	14.89	16.89	/	/	/	0.63	-0.17	2.29	2.98	/	/	/
69	20.90	0.22	-1.32	7.44	11.82	15.34	/	/	/	/	0.56	1.69	3.52	/	/	/	/
70	20.08	0.39	-1.34	8.17	12.01	14.62	16.38	17.57	/	/	2.31	1.20	1.33	0.84	1.65	/	/
71	19.32	0.50	-1.03	7.82	12.37	15.12	16.78	/	/	/	1.50	1.90	1.25	1.05	/	/	/
72	22.18	0.35	-1.25	7.76	11.97	14.95	17.06	18.56	/	/	1.17	0.13	2.46	1.22	1.71	/	/
73	21.23	0.42	-1.06	7.60	12.27	15.34	17.36	/	/	/	1.79	0.82	0.86	1.68	/	/	/
74	19.49	0.48	-1.03	7.59	12.11	14.92	16.66	/	/	/	0.65	0.06	2.70	2.70	/	/	/
75	19.34	0.30	-1.62	7.38	10.45	12.73	14.43	15.69	/	/	0.68	1.84	2.40	0.60	2.62	/	/
76	22.40	0.29	-1.61	7.62	10.85	13.26	15.06	16.41	/	/	0.93	1.86	0.59	0.51	0.36	/	/
77	20.02	0.34	-1.59	7.88	11.06	13.33	14.96	16.12	/	/	2.03	0.85	0.82	0.53	3.61	/	/
78	22.02	0.22	-1.55	6.46	9.59	12.08	14.08	/	/	/	2.63	1.23	1.48	7.34	/	/	/
79	18.60	0.35	-1.67	8.25	11.31	13.46	14.98	/	/	/	3.65	2.83	1.56	2.12	/	/	/
80	19.89	0.44	-1.11	7.67	12.01	14.80	16.61	/	/	/	0.65	2.39	1.24	1.67	/	/	/
81	23.40	0.35	-1.11	7.59	12.29	15.59	/	/	/	/	0.61	2.81	3.57	/	/	/	/
82	20.01	0.37	-1.54	8.66	12.16	14.57	16.25	/	/	/	2.84	2.18	0.97	1.10	/	/	/
83	20.80	0.32	-1.45	7.77	11.36	13.95	15.84	/	/	/	1.05	1.53	0.48	0.50	/	/	/
84	20.90	0.14	-1.39	7.55	12.14	16.15	/	/	/	/	0.64	0.14	2.73	/	/	/	/
85	21.11	0.40	-1.22	8.16	12.43	15.29	17.21	/	/	/	2.52	1.77	1.43	3.73	/	/	/
86	20.70	0.04	-1.65	7.57	11.93	16.11	/	/	/	/	0.63	-0.02	2.87	/	/	/	/
87	19.59	0.45	-1.08	7.60	11.98	14.76	16.52	17.65	/	/	0.63	0.27	1.14	0.76	2.81	/	/
88	21.80	0.35	-1.31	7.95	12.00	14.87	16.90	/	/	/	1.89	0.85	0.65	4.34	/	/	/
89	19.81	0.31	-1.60	7.77	10.99	13.35	15.08	16.35	/	/	1.44	0.84	0.58	0.59	2.51	/	/
90	20.08	0.39	-1.20	7.55	11.63	14.38	16.24	/	/	/	0.73	1.39	2.69	1.66	/	/	/
91	22.13	0.29	-1.69	7.89	11.01	13.33	15.07	16.36	/	/	2.53	1.13	1.13	0.72	2.47	/	/
92	22.31	0.31	-1.44	8.02	11.81	14.60	16.64	/	/	/	2.31	1.52	1.17	5.82	/	/	/
93	21.00	0.53	-0.88	7.48	12.63	15.65	/	/	/	/	0.59	1.54	3.18	/	/	/	/
94	19.09	0.40	-1.47	8.47	11.95	14.29	15.87	/	/	/	2.53	1.89	0.44	0.87	/	/	/
95	21.89	0.34	-1.21	7.46	11.66	14.64	16.75	/	/	/	0.51	-0.17	4.95	4.88	/	/	/
96	19.82	0.47	-1.12	8.04	12.43	15.18	/	/	/	/	2.75	2.23	2.70	/	/	/	/
97	19.60	0.51	-0.97	7.68	12.46	15.33	/	/	/	/	0.78	1.69	0.50	/	/	/	/
98	20.15	0.19	-1.33	7.57	12.12	15.86	/	/	/	/	0.61	1.38	3.07	/	/	/	/
99	21.00	0.06	-1.51	7.61	12.25	16.61	/	/	/	/	0.62	0.31	2.32	/	/	/	/
100	21.11	0.26	-1.81	7.88	10.89	13.22	15.01	/	/	/	2.11	1.12	1.13	4.50	/	/	/

Appendix Table B.11c Estimates and corresponding percentage bias of the demographic parameters computed by means of the ELEFAN I method and the EM algorithm in the sub-sampling of 1000 length measurements extracted from the Red mullet hypothetical population.

	Sample size = 1000 length measurements																			
	% Bias																			
	ELEFAN I method																			
	L_∞	k	t_0	mean 1	mean 2	mean 3	mean 4	mean 5	mean 6	mean 7	SD 1	SD 2	SD 3	SD 4	SD 5	SD 6	SD 7
1	-4.53	-57.45	328.81	-3.36	-5.27	-16.32	-12.58	-2.07	/	/	66.49	-210.46	-71.02	-77.38	-93.94	/	/
2	7.88	-44.68	36.48	-1.17	1.12	0.58	/	/	/	/	125.40	-85.62	-71.02	/	/	/	/
3	0.24	-57.45	235.12	3.41	-4.66	-4.10	-6.98	/	/	/	-51.33	-59.34	-56.54	-59.53	/	/	/
4	-4.06	-36.17	86.50	4.30	-1.58	5.26	/	/	/	/	-7.79	-164.47	-65.23	/	/	/	/
5	0.72	-36.17	30.28	0.07	3.10	0.52	/	/	/	/	130.52	-52.77	-78.27	/	/	/	/
6	-2.15	-36.17	33.09	-0.28	0.35	-2.32	/	/	/	/	63.93	58.92	-66.68	/	/	/	/
7	2.63	-57.45	248.04	-1.12	-2.15	-1.13	-2.13	/	/	/	12.70	-52.77	-66.68	-77.38	/	/	/
8	-3.10	-53.19	307.01	-5.19	-2.15	4.73	-0.07	/	/	/	25.51	-59.34	-60.88	-89.29	/	/	/
9	-0.24	-53.19	242.42	-4.18	0.91	-0.50	-0.08	/	/	/	-23.16	-85.62	-68.13	-67.86	/	/	/
10	5.49	-40.43	37.06	2.32	3.53	2.62	/	/	/	/	53.68	-138.19	-55.09	/	/	/	/
11	-5.97	-57.45	435.80	-1.09	0.85	-3.68	-4.26	-5.24	/	/	94.66	-184.18	-84.06	-89.29	-82.83	/	/
12	-1.67	-53.19	64.17	1.17	-5.91	-17.63	-21.31	-17.66	-17.28	/	5.02	-236.74	-75.37	-85.72	-74.75	-86.58	/
13	-4.53	-57.45	294.71	0.54	-1.54	-16.42	-9.78	-7.75	/	/	-7.79	-85.62	-33.36	-78.57	-77.78	/	/
14	4.06	-57.45	237.49	-1.74	-0.86	-3.43	0.13	/	/	/	-33.41	-85.62	-76.82	-90.48	/	/	/
15	0.24	-53.19	252.55	1.34	1.60	4.23	-1.53	/	/	/	74.17	-52.77	-75.37	-79.77	/	/	/
16	-7.40	-27.66	58.29	-1.15	2.51	3.74	/	/	/	/	2.45	32.64	-76.82	/	/	/	/
17	-5.97	-31.91	56.64	-0.96	0.21	2.05	/	/	/	/	20.38	-223.60	-53.64	/	/	/	/
18	-6.44	-48.94	257.79	-0.82	-0.32	-0.15	-3.29	/	/	/	51.12	-125.05	-60.88	-77.38	/	/	/
19	-4.53	-57.45	354.41	4.81	4.21	-8.84	-9.57	-5.82	/	/	7.58	-197.32	-81.17	-72.62	-90.91	/	/
20	-2.63	-31.91	36.30	-4.41	3.86	2.71	-97.67	/	/	/	71.61	-65.91	/	/	/	/	/
21	-2.15	-48.94	173.54	3.09	4.35	-4.50	-5.43	/	/	/	33.19	-111.91	-56.54	-61.91	/	/	/
22	-4.06	-57.45	166.95	-1.64	-8.21	-19.60	-17.08	-16.69	/	/	17.82	-282.73	-40.60	-84.53	-84.85	/	/
23	-1.67	-40.43	78.25	3.21	-3.43	2.84	/	/	/	/	56.24	-157.90	-72.47	/	/	/	/
24	-7.40	-31.91	61.86	-0.66	-1.18	1.08	/	/	/	/	71.61	-131.62	-69.58	/	/	/	/
25	-0.24	-53.19	206.65	-2.66	1.08	-3.02	-4.04	/	/	/	81.86	-151.33	-72.47	-79.77	/	/	/
26	-10.26	-57.45	384.65	3.65	0.24	0.44	/	/	/	/	76.73	-164.47	-56.54	/	/	/	/
27	-4.53	-48.94	203.05	0.51	1.74	-3.01	-5.52	/	/	/	-82.07	-59.34	-66.68	-64.29	/	/	/
28	1.67	-57.45	251.87	-2.85	-3.10	-0.78	-3.14	/	/	/	79.29	-177.61	-78.27	-94.05	/	/	/
29	1.67	-57.45	166.19	-0.42	-3.15	-17.85	-7.46	/	/	/	71.61	-118.48	-26.11	-73.81	/	/	/
30	0.24	-57.45	179.35	0.27	-2.02	-12.16	-14.42	-12.16	/	/	104.91	-223.60	-73.92	-78.57	-83.84	/	/
31	-2.63	-36.17	53.48	-1.25	-0.06	1.79	/	/	/	/	84.42	-138.19	-69.58	/	/	/	/
32	-5.49	-27.66	43.41	-3.46	4.54	3.86	/	/	/	/	12.70	-131.62	-52.19	/	/	/	/
33	-0.72	-40.43	61.91	0.77	-2.39	1.14	/	/	/	/	-53.90	-144.76	-59.43	/	/	/	/
34	1.19	-53.19	201.36	-2.70	2.59	0.66	-4.87	/	/	/	43.44	-111.91	-75.37	-78.57	/	/	/
35	8.35	-44.68	29.41	0.16	1.45	-1.06	/	/	/	/	97.22	-118.48	-71.02	/	/	/	/
36	0.72	-40.43	71.74	-1.50	-0.99	5.39	/	/	/	/	38.31	-92.19	-76.82	/	/	/	/
37	-1.67	-40.43	84.92	0.08	-3.29	4.65	/	/	/	/	-64.14	-79.05	-40.60	/	/	/	/
38	5.49	-44.68	54.74	0.97	-1.16	1.92	/	/	/	/	-74.39	-105.33	-71.02	/	/	/	/
39	2.15	-53.19	67.86	-3.71	-6.29	-17.32	-13.78	/	/	/	46.00	-223.60	-84.06	-77.38	/	/	/
40	-3.10	-44.68	-18.19	1.47	-6.92	-17.59	-20.53	-15.88	-18.00	/	22.94	-230.17	-68.13	-77.38	-73.74	-78.29	/
41	-3.10	-48.94	163.09	-2.55	3.57	-4.30	-8.26	/	/	/	58.80	-79.05	-60.88	-60.72	/	/	/
42	7.88	-57.45	84.69	0.91	-1.28	-14.63	-16.52	-14.04	-9.56	/	92.10	-125.05	-71.02	-80.96	-76.77	-96.71	/
43	-11.22	-48.94	152.76	-6.63	1.79	-100.00	/	/	/	/	-43.65	-197.32	/	/	/	/	/
44	0.72	-57.45	229.91	0.74	-4.22	-4.63	-6.19	/	/	/	28.07	-171.04	-73.92	-70.24	/	/	/
45	-4.53	-36.17	74.59	-3.32	-2.16	3.90	/	/	/	/	-0.11	-157.90	-68.13	/	/	/	/
46	-1.19	-48.94	104.62	1.13	-3.88	-15.54	-5.88	/	/	/	28.07	-79.05	-46.39	-72.62	/	/	/
47	4.53	-57.45	180.53	1.95	-0.46	-6.02	-7.85	/	/	/	117.71	-59.34	-65.23	-78.57	/	/	/
48	-6.44	-57.45	335.34	3.99	2.13	-7.12	-11.72	-11.26	/	/	53.68	-92.19	-68.13	-70.24	-81.82	/	/
49	0.72	-57.45	254.19	-0.75	-4.09	-0.07	-5.25	/	/	/	30.63	-171.04	-79.72	-78.57	/	/	/
50	2.15	-53.19	-15.04	-4.74	-5.93	-19.17	-19.16	-19.78	-20.45	-19.50	38.31	-177.61	-60.88	-84.53	-81.82	-89.34	-97.67
51	0.24	-53.19	194.82	-1.44	1.37	-2.97	-5.29	/	/	/	-94.88	-13.35	-49.29	-72.62	/	/	/
52	-7.88	-48.94	268.59	-1.25	-1.71	0.57	-5.05	/	/	/	51.12	-111.91	-69.58	-76.19	/	/	/
53	0.72	-57.45	221.57	2.99	-4.07	-1.65	-10.26	/	/	/	94.66	-190.75	-75.37	-60.72	/	/	/
54	0.24	-53.19	221.68	4.75	1.45	-0.85	-3.26	/	/	/	81.86	-85.62	-72.47	-82.15	/	/	/
55	-6.92	-48.94	121.09	-2.04	0.62	-100.00	/	/	/	/	69.05	-79.05	/	/	/	/	/
56	-1.67	-36.17	54.13	-1.11	0.92	3.08	/	/	/	/	40.87	-138.19	-47.84	/	/	/	/
57	-5.01	-31.91	45.77	-3.49	1.30	1.55	/	/	/	/	20.38	-98.76	-65.23	/	/	/	/
58	-0.72	-53.19	152.68	-1.54	-2.27	-8.92	-11.36	-11.73	-12.19	/	145.89	-276.16	-73.92	-83.34	-89.90	-96.71	/
59	-0.24	-40.43	89.29	-1.65	-2.00	7.59	/	/	/	/	86.98	-111.91	-84.06	/	/	/	/
60	-4.53	-57.45	315.77	2.26	-1.52	-7.37	-10.38	-8.54	/	/	20.38	-190.75	-52.19	-77.38	-87.88	/	/
61	-7.40	-27.66	55.52	0.26	2.38	3.09	/	/	/	/	58.80	6.36	-59.43	/	/	/	/
62	-4.53	-36.17	86.26	3.36	-2.16	4.81	/	/	/	/	15.26	-184.18	-65.23	/	/	/	/
63	0.24	-36.17	25.97	-3.61	2.96	-0.51	/	/	/	/	-89.75	-190.75	-65.23	/	/	/	/
64	-6.92	-48.94	178.23	0.90	-0.79	-9.03	-9.78	/	/	/	76.73	-243.31	-76.82	-73.81	/	/	/
65	-6.44	-48.94	217.98	1.66	-0.29	-2.14	-7.51	/	/	/	69.05	-111.91	-62.33	-71.43	/	/	/
66	8.83	-53.19	16.36	-0.63	-4.00	-16.37	-11.53	-14.40	/	/	71.61	-230.17	-72.47	-86.91	-72.73	/	/
67	-11.69	-44.68	240.74	-3.61	-1.31	-3.46	-7.31	/	/	/	43.44	6.36	-57.98	-75.00	/	/	/
68	-4.06	-53.19	235.38	-1.16	-3.03	-2.32	-6.96	/	/	/	92.10	-125.05	-75.37	-69.05	/	/	/
69	10.26	-48.94	43.43	-5.22	-2.22	0.25	/	/	/	/	35.75	-92.19	-59.43	/	/	/	/
70	-4.06	-57.45	322.82	-3.12	4.76	-2.54	-9.43	-10.74	/	/	89.54	-125.05	-86.96	-90.48	-87.88	/	/
71	-7.88	-48.94	281.76	1.30	-1.71	-2.72	-2.10	/	/	/	-71.83	-33.06	-66.68	-71.43	/	/	/
72	5.97	-44.68	40.65	2.87	1.22	-0.56	-5.99	-5.93	/	/	53.68	-85.62	-57.98	-72.62	-83.84	/	/
73	1.19	-57.45	278.24	-1.21	-3.82	0.53	-1.15	/	/	/	148.45	-190.75	-72.47	-77.38	/	/	/
74	-1.67	-53.19	198.30	1.18	-0.45	-3.75	-7.99	/	/	/	-10.35	-197.32	-86.96	-76.19	/	/	/
75	-7.88	-57.45	204.91	-5.91	-36.40	-19.55	-16.19	-12.42	/	/	5.02	223.17	-78.27	-73.81	-84.85	/	/
76	-2.63	-57.45	235.69	-4.23	1.32	-14.73	-14.02	-9.29	/	/	43.44	-26.49	-55.09	-65.48	-83.84	/	/
77	-9.31	-57.45	328.94	2.52	-2.06	-13.86	-14.00	-13.14	/	/	92.10	-223.60	-69.58	-71.43	-77.78	/	/
78	5.01	-57.45	64.73	-2.63	-34.62	-19.92	-8.15	/	/	/	92.10	85.20	-50.74	-70.24	/	/	/
79	-11.22	-36.17	48.59	-2.81	-2.69	-14.13	-15.08	/	/	/	53.68	-138.19	-92.76	-84.53	/	/	/
80	-5.01	-48.94	206.35	3.12	1.13	-2.31	-6.65	/	/	/	-2.67	-92.19	-59.43	-75.00	/	/	/
81	11.69	-44.68	27.89	-1.40	4.55	2.74	/	/	/	/	38.31	-98.76	-68.13	/	/	/	/
82	-4.53	-53.19	215.94	5.05	-3.52	-4.34	-10.40	/	/	/	-94.88	-144.76	-37.70	-44.06	/	/	/
83	-0.72	-53.19	161.09	2.64	0.54	-8.61	-9.98	/	/	/	61.36	-65.91	-69.58	-76.19	/	/	/
84	-6.44	-31.91	63.25	3.87	-0.39	1.86	/	/	/	/	-46.21	-322.15	-47.84	/	/	/	/
85	0.72	-53.19	233.92	2.25	2.08	0.75	-1.27	/	/	/	110.03	-52.77	-57.98	-79.77	/	/	/
86	-1.67	-40.43	80.38	2.36	-3.36	3.39	/	/	/	/	-20.60	-157.90	-47.84	/	/	/	/
87	-6.44	-57.45	381.43	3.74	1.96	-1.92	-7.88	-11.05	/	/	-20.60	-144.76	-86.96	-72.62	-75.76	/	/
88	4.06	-53.19	136.90	0.95	5.30	-4.45	-9.31	/	/	/	53.68	-151.33	-71.02	-70.24	/	/	/
89	-5.49	-53.19	213.73	2.19	-1.45	-12.80	-13.51	-9.93	/	/	112.59	-243.31	-62.33	-83.34	-92.93	/	/
90	-4.06	-48.94	104.40	0.11	-2.62	-18.05	-10.43	/	/	/	15.26	-59.34	-39.15	-77.38	/	/	/
91	-4.06	-57.45	216.34	1.59	-1.98	-16.00	-13.95	-14.91	/	/	115.15	-236.74	-75.37	-80.96	-89.90	/	/
92	6.44	-57.45	179.14	-1.18	1.31	-5.36	-4.79	/	/	/	125.40	-79.05	-59.43	-71.43	/	/	/
93	-12.17	-57.45	431.57	-3.47	2.60	1.42	/	/	/	/	-0.11	-65.91	-39.15	/	/	/	/
94	-8.83	-48.94	197.90	-2.21	-2.71	-6.08	-11.68	/	/	/	-0.11	-197.32	-88.41	-89.29	/	/	/
95	4.53	-57.45	105.33	-5.57	-4.90	-20.25	-10.82	/	/	/	17.82	-144.76	-26.11	-85.72	/	/	/
96	-5.49	-36.17	87.57	1.77	-3.12	4.07	/	/	/	/	86.98	-243.31	-71.02	/	/	/	/
97	-6.44	-31.91	50.79	4.67	-0.35	-0.73	/	/	/	/	20.38	-111.91	-81.17	/	/	/	/
98	-0.24	-40.43	66.48	-0.66	-1.99	3.01	/	/	/	/	61.36	-111.91	-68.13	/	/	/	/
99	3.10	-40.43	69.15	-0.79	1.16	7.75	/	/	/	/	-28.28	-217.03	-62.33	/	/	/	/
100	0.72	-57.45	169.33	1.95	-4.12	-15.90	-9.87	/	/	/	112.59	-203.89	-44.95	-66.67	/	/	/

Appendix Table B.11d Estimates and corresponding percentage bias of the demographic parameters computed by means of the ELEFAN I method and the EM algorithm in the sub-sampling of 1000 length measurements extracted from the Red mullet hypothetical population.

Sample size = 1000 length measurements																	
% Bias																	
EM algorithm																	
	L_∞	*k*	t_0	*mean 1*	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*mean 7*	*SD 1*	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*	*SD 7*
1	-0.95	-28.82	106.73	1.24	-7.54	-9.34	-9.73	-8.47	/	/	249.84	44.59	47.22	30.24	793.44	/	/
2	7.90	-31.72	101.30	8.19	0.40	-0.67	/	/	/	/	424.53	80.63	170.99	/	/	/	/
3	4.01	-27.21	80.45	0.60	-3.11	-3.18	-2.74	/	/	/	-0.73	-4.19	57.77	110.80	/	/	/
4	-1.77	-90.50	127.47	-0.49	-0.63	7.90	/	/	/	/	-6.35	-0.46	122.78	/	/	/	/
5	0.69	-12.65	72.03	8.26	3.62	1.97	/	/	/	/	315.50	81.02	86.21	/	/	/	/
6	-2.17	-8.51	56.18	1.14	0.35	-0.40	/	/	/	/	52.11	63.08	-6.50	/	/	/	/
7	2.63	-14.98	55.62	-0.15	0.41	0.72	0.65	/	/	/	11.11	34.06	-57.58	-23.23	/	/	/
8	-3.12	-1.96	44.05	-0.75	1.08	0.57	-0.57	/	/	/	23.54	-1.52	88.01	-78.45	/	/	/
9	1.39	-11.50	49.82	-1.20	0.49	0.85	0.61	/	/	/	-3.64	14.00	101.44	65.06	/	/	/
10	14.86	-22.41	48.80	0.06	4.23	6.55	/	/	/	/	-2.09	26.30	164.07	/	/	/	/
11	-5.72	-6.47	68.96	5.37	0.53	-1.71	-3.39	-3.47	/	/	285.40	39.14	132.68	27.46	173.90	/	/
12	-1.65	-50.32	191.77	2.84	-13.55	-16.83	-17.07	-15.17	-15.02	/	2.69	-13.94	-71.32	-59.50	110.46	-52.53	/
13	-4.40	-16.77	73.35	-0.41	-4.28	-5.32	-5.92	-5.14	/	/	-2.02	-5.11	67.98	-32.07	138.68	/	/
14	4.04	-21.84	64.63	-1.01	-1.73	-1.22	-0.80	/	/	/	-26.14	60.20	-65.56	-43.96	/	/	/
15	0.23	-0.77	40.42	1.60	4.53	4.22	3.07	/	/	/	84.49	44.05	-62.04	-37.16	/	/	/
16	-7.43	32.36	12.78	-0.98	7.44	5.54	/	/	/	/	2.21	50.27	-24.45	/	/	/	/
17	0.91	-66.29	95.22	-0.37	0.34	6.24	/	/	/	/	-2.47	4.62	152.99	/	/	/	/
18	-6.37	1.11	47.40	0.04	0.21	-1.08	-2.70	/	/	/	86.67	-2.45	169.00	45.37	/	/	/
19	-4.55	-18.55	84.57	2.66	-3.64	-5.35	-6.19	-5.48	/	/	7.91	-9.96	-70.15	57.63	-73.70	/	/
20	-2.63	8.99	28.71	-0.77	4.74	4.28	/	/	/	/	79.05	64.50	66.05	/	/	/	/
21	-10.88	26.92	24.64	-0.32	3.62	1.13	-2.18	/	/	/	2.76	6.70	106.64	126.73	/	/	/
22	-4.11	-43.88	172.04	4.37	-11.31	-14.67	-15.21	-13.66	/	/	10.70	-13.36	148.04	-42.52	-77.15	/	/
23	-1.60	-6.91	61.26	5.72	3.06	1.56	/	/	/	/	339.36	64.46	116.20	/	/	/	/
24	-7.29	2.31	56.92	4.87	1.82	-0.59	/	/	/	/	308.16	71.84	138.53	/	/	/	/
25	-0.21	-13.07	59.47	0.75	-0.17	-0.54	-1.02	/	/	/	87.91	40.00	-3.76	323.77	/	/	/
26	-9.98	19.32	33.58	1.26	3.02	0.58	/	/	/	/	20.98	101.72	211.58	/	/	/	/
27	-4.47	-6.15	61.16	3.24	0.54	-1.04	-2.44	/	/	/	152.32	54.03	3.11	-16.41	/	/	/
28	1.69	-16.34	62.65	1.16	-0.05	-0.22	-0.43	/	/	/	278.37	40.07	14.15	18.27	/	/	/
29	1.66	-22.75	74.26	0.27	-2.77	-3.00	-2.89	/	/	/	54.41	-6.96	141.76	15.45	/	/	/
30	0.27	-45.27	168.61	5.99	-9.31	-12.36	-12.64	-10.82	/	/	291.93	44.02	-44.76	-57.60	93.84	/	/
31	-2.53	-4.89	57.73	4.67	2.70	1.23	/	/	/	/	371.54	70.41	128.43	/	/	/	/
32	8.37	-13.34	40.82	-1.22	3.88	5.54	/	/	/	/	4.19	36.70	170.89	/	/	/	/
33	-0.29	-83.89	123.11	-0.35	-1.23	6.05	/	/	/	/	-4.04	-3.49	153.98	/	/	/	/
34	1.19	-9.39	47.44	-0.79	1.28	1.56	1.16	/	/	/	48.69	18.89	-68.08	-21.01	/	/	/
35	25.52	-36.41	62.35	-0.36	2.38	5.69	/	/	/	/	-6.70	10.53	161.60	/	/	/	/
36	0.70	2.99	31.23	-0.35	5.29	5.46	/	/	/	/	39.35	66.06	59.78	/	/	/	/
37	0.14	-89.51	134.98	0.12	-1.47	6.16	/	/	/	/	0.54	0.12	110.20	/	/	/	/
38	5.49	-10.86	43.94	0.13	3.69	4.59	/	/	/	/	110.24	64.99	43.09	/	/	/	/
39	2.18	-50.76	172.97	0.65	-13.44	-15.78	-15.46	/	/	/	260.44	44.36	-30.46	112.73	/	/	/
40	-3.06	-46.92	169.98	0.46	-13.92	-16.66	-16.75	-14.86	-14.81	/	-1.84	6.06	-42.79	-43.87	-62.51	122.81	/
41	-16.64	46.74	17.33	-0.63	3.05	-1.10	-5.70	/	/	/	0.61	11.66	157.45	110.52	/	/	/
42	8.07	-54.81	195.46	5.91	-10.56	-13.45	-13.19	-10.69	-10.07	/	255.01	21.25	-38.39	-25.51	-13.30	195.63	/
43	-1.68	37.01	10.08	-4.28	4.37	/	/	/	/	/	-38.35	91.70	/	/	/	/	/
44	4.66	-25.92	74.25	-0.17	-2.62	-2.35	-1.81	/	/	/	0.83	1.96	58.87	101.98	/	/	/
45	-0.72	-97.24	144.32	-1.27	-2.54	6.17	/	/	/	/	-16.08	54.56	165.36	/	/	/	/
46	-1.16	-41.16	134.73	-0.50	-11.41	-13.14	-12.91	/	/	/	19.74	50.52	-7.49	215.84	/	/	/
47	4.55	-30.00	92.68	3.28	-2.74	-3.37	-3.07	/	/	/	260.49	20.14	-38.31	27.67	/	/	/
48	-6.50	-22.49	100.25	3.08	-5.76	-8.05	-8.98	-8.24	/	/	98.15	63.94	-42.33	-43.74	-41.63	/	/
49	7.40	-27.60	72.23	-0.37	-2.01	-1.28	-0.41	/	/	/	-4.10	-5.68	72.70	114.28	/	/	/
50	2.12	-64.31	359.54	17.40	-10.50	-17.56	-19.42	-18.22	-18.21	-19.39	248.85	-10.78	-58.83	-81.43	-80.10	48.15	-71.30
51	0.27	-27.29	114.76	11.04	-0.37	-3.13	-4.04	/	/	/	264.19	64.78	-32.56	-59.01	/	/	/
52	-7.77	14.65	31.63	-0.51	2.80	1.21	-1.20	/	/	/	143.07	25.70	-8.58	381.82	/	/	/
53	3.26	-22.71	71.02	0.37	-1.88	-1.82	-1.57	/	/	/	-0.48	-6.51	80.17	134.50	/	/	/
54	0.27	-12.52	67.31	5.63	2.33	1.11	0.19	/	/	/	248.63	26.37	-32.78	120.00	/	/	/
55	-6.92	26.30	16.68	-1.43	6.15	/	/	/	/	/	-25.75	92.80	/	/	/	/	/
56	-5.06	-74.08	106.83	0.19	0.17	6.71	/	/	/	/	-0.96	-4.02	140.58	/	/	/	/
57	6.55	-16.26	48.78	-1.23	1.70	2.93	/	/	/	/	-13.55	48.09	175.12	/	/	/	/
58	-0.68	-39.82	144.39	5.02	-8.08	-10.65	-10.91	-9.23	/	/	178.56	-5.86	-64.38	-69.23	-8.67	/	/
59	-0.19	-12.53	68.97	5.94	2.18	0.82	/	/	/	/	330.89	72.84	148.11	/	/	/	/
60	-4.60	-18.61	82.35	1.60	-4.13	-5.65	-6.39	-5.63	/	/	15.53	-12.49	132.57	-46.60	-73.93	/	/
61	-7.41	23.36	22.20	-0.20	5.45	3.68	/	/	/	/	48.03	69.15	33.11	/	/	/	/
62	-0.24	-91.69	130.13	-0.11	-0.43	8.19	/	/	/	/	0.59	-0.05	130.88	/	/	/	/
63	-9.44	21.32	26.08	-1.29	3.02	1.13	/	/	/	/	-10.63	53.70	207.59	/	/	/	/
64	-6.87	-16.33	87.37	3.45	-3.89	-6.14	-7.34	/	/	/	205.93	32.07	2.20	197.11	/	/	/
65	3.16	1.34	51.91	2.55	1.25	-0.54	-2.39	/	/	/	198.29	18.06	-38.80	152.60	/	/	/
66	8.86	-46.05	126.19	-0.77	-9.58	-10.05	-8.84	-5.96	/	/	10.77	28.38	36.62	-6.54	356.36	/	/
67	-6.95	14.16	39.70	-0.65	-0.22	-2.53	-5.16	/	/	/	40.08	46.84	-44.28	-63.34	/	/	/
68	0.38	-16.27	61.22	-0.77	-1.58	-1.62	-1.78	/	/	/	-3.06	-8.17	99.04	112.93	/	/	/
69	-0.24	-54.16	89.03	-2.05	-2.50	1.38	/	/	/	/	-14.07	50.06	206.03	/	/	/	/
70	-4.17	-17.03	91.40	7.50	-0.88	-3.42	-4.73	-4.31	/	/	255.10	34.85	15.51	-40.09	0.18	/	/
71	-7.77	7.01	47.33	2.89	2.02	-0.13	-2.42	/	/	/	130.79	56.69	8.44	-24.82	/	/	/
72	5.86	-26.50	78.06	2.09	-1.24	-1.21	-0.76	1.04	/	/	79.23	1.34	113.66	-13.06	3.40	/	/
73	1.32	-10.73	50.96	0.03	1.23	1.35	0.95	/	/	/	174.66	22.68	-25.42	19.67	/	/	/
74	-6.97	1.81	47.23	-0.17	-0.07	-1.43	-3.12	/	/	/	-0.11	-0.95	135.02	92.76	/	/	/
75	-7.67	-36.86	131.24	-2.93	-13.79	-15.87	-16.07	-14.56	/	/	5.15	54.84	108.66	-56.86	58.57	/	/
76	6.92	-38.14	129.95	0.32	-10.51	-12.41	-12.41	-10.67	/	/	42.43	55.46	-48.36	-63.68	-78.36	/	/
77	-4.43	-28.50	127.35	3.67	-8.76	-11.91	-13.01	-12.24	/	/	211.30	23.91	-28.86	-62.21	118.81	/	/
78	5.11	-52.34	121.66	-14.94	-20.91	-20.18	-18.13	/	/	/	304.49	35.60	28.87	424.35	/	/	/
79	-11.21	-25.49	138.93	8.50	-6.73	-11.06	-12.88	/	/	/	460.96	85.71	35.60	51.39	/	/	/
80	-5.05	-6.85	59.07	0.99	-0.95	-2.20	-3.41	/	/	/	0.28	71.87	7.41	19.61	/	/	/
81	11.68	-25.03	59.02	-0.11	1.36	2.97	/	/	/	/	-6.10	85.13	210.74	/	/	/	/
82	-4.50	-21.73	120.37	14.00	0.28	-3.72	-5.51	/	/	/	337.17	65.25	-15.42	-21.43	/	/	/
83	-0.73	-31.52	107.67	2.26	-6.31	-7.80	-7.88	/	/	/	61.50	45.09	-58.19	-64.26	/	/	/
84	-0.24	-71.02	99.09	-0.72	0.17	6.73	/	/	/	/	-0.89	1.60	137.68	/	/	/	/
85	0.78	-14.92	74.57	7.39	2.55	1.04	0.11	/	/	/	287.94	52.59	24.31	166.72	/	/	/
86	-1.19	-91.60	135.51	-0.41	-1.61	6.47	/	/	/	/	-3.02	-3.39	149.29	/	/	/	/
87	-6.48	-3.30	54.17	-0.06	-1.18	-2.49	-3.89	-3.92	/	/	-3.47	5.54	-1.29	-45.65	70.12	/	/
88	4.07	-26.34	87.06	4.56	-0.99	-1.75	-1.71	/	/	/	190.18	23.82	-43.13	209.72	/	/	/
89	-5.45	-33.73	128.38	2.23	-9.32	-11.79	-12.29	-11.00	/	/	120.62	23.33	-49.43	-58.02	52.00	/	/
90	-4.13	-16.29	71.22	-0.64	-4.07	-5.00	-5.57	/	/	/	12.71	40.75	133.94	18.25	/	/	/
91	5.61	-37.36	141.43	3.80	-9.17	-11.90	-12.37	-10.94	/	/	289.49	32.55	-1.94	-48.35	49.79	/	/
92	6.48	-34.36	106.14	5.46	-2.57	-3.56	-3.19	/	/	/	254.42	44.83	2.13	315.89	/	/	/
93	0.24	13.34	26.12	-1.58	4.16	3.37	/	/	/	/	-9.39	45.24	176.80	/	/	/	/
94	-8.86	-15.44	110.68	11.43	-1.39	-5.55	-7.70	/	/	/	288.51	56.19	-62.03	-37.96	/	/	/
95	4.49	-26.77	72.86	-1.89	-3.81	-3.28	-2.57	/	/	/	-22.36	-8.02	329.95	248.31	/	/	/
96	-5.40	-0.80	59.49	5.81	2.55	0.31	/	/	/	/	323.02	66.97	134.72	/	/	/	/
97	-6.46	9.19	38.52	1.08	2.83	1.27	/	/	/	/	19.92	49.93	-56.46	/	/	/	/
98	-3.82	-58.79	89.46	-0.45	-0.05	4.81	/	/	/	/	-5.69	40.41	166.98	/	/	/	/
99	0.24	-86.23	115.70	0.12	1.10	9.73	/	/	/	/	-5.38	6.97	102.09	/	/	/	/
100	0.79	-45.10	158.77	3.73	-10.14	-12.67	-12.68	/	/	/	224.39	32.14	-1.86	221.45	/	/	/

Appendix Table B.12a Estimates and corresponding percentage bias of the demographic parameters computed by means of the ELEFAN I method and the EM algorithm in the sub-sampling of 1000 length measurements extracted from the European hake hypothetical population.

Sample size = 1000 length measurements																
Estimates																
ELEFAN I method																
	L_∞ (cm)	k (year-1)	t_0 (year)	mean 1 (cm)	mean 2 (cm)	mean 3 (cm)	mean 4 (cm)	mean 5 (cm)	mean 6 (cm)	SD 1 (cm)	SD 2 (cm)	SD 3 (cm)	SD 4 (cm)	SD 5 (cm)	SD 6 (cm)
1	106.00	0.05	-4.34	19.25	26.39	33.32	43.84	/	/	4.83	4.78	6.53	10.42	/	/
2	79.00	0.07	-3.89	19.31	27.88	31.17	36.28	/	/	2.33	3.44	6.86	11.92	/	/
3	85.00	0.09	-2.72	20.13	26.35	39.99	/	/	/	3.00	2.61	3.36	/	/	/
4	58.00	0.08	-9.11	19.12	27.52	33.65	41.60	48.16	/	3.00	6.78	4.03	12.09	7.01	/
5	106.00	0.04	-6.02	19.22	26.58	33.74	39.83	40.99	/	4.00	3.44	1.20	11.42	8.51	/
6	81.00	0.07	-4.39	19.78	27.60	33.28	42.71	/	/	3.83	5.78	7.20	11.09	/	/
7	61.00	0.13	-2.56	19.74	27.44	33.42	/	/	/	6.33	8.78	6.20	/	/	/
8	103.00	0.07	-2.86	19.48	26.84	41.24	/	/	/	15.00	3.44	7.20	/	/	/
9	93.00	0.06	-4.24	19.83	26.70	33.37	43.57	/	/	7.67	3.94	4.86	11.76	/	/
10	70.00	0.11	-2.46	19.69	27.56	33.27	/	/	/	0.33	5.44	7.20	/	/	/
11	69.00	0.08	-4.93	18.87	26.70	32.38	43.76	/	/	2.33	3.28	5.20	13.92	/	/
12	77.00	0.06	-6.34	19.96	28.23	33.03	41.29	41.18	/	4.33	6.61	3.03	12.92	9.18	/
13	103.00	0.07	-2.79	19.53	27.28	39.91	/	/	/	19.50	6.11	5.36	/	/	/
14	79.00	0.07	-4.38	19.28	26.89	32.42	41.65	/	/	1.33	5.11	7.20	12.09	/	/
15	76.00	0.06	-6.13	19.73	27.18	32.95	39.08	40.28	/	2.00	4.94	4.70	12.76	10.68	/
16	101.00	0.11	-0.83	19.94	25.75	/	/	/	/	8.67	4.78	/	/	/	/
17	67.00	0.09	-4.34	20.22	26.55	34.76	40.64	/	/	1.83	0.94	6.03	14.76	/	/
18	107.00	0.04	-6.71	19.34	28.48	32.89	42.15	47.93	/	7.67	5.61	6.03	10.09	7.34	/
19	88.00	0.06	-4.46	18.76	27.53	33.93	39.99	/	/	5.00	2.78	5.86	13.42	/	/
20	63.00	0.06	-8.99	19.03	27.68	32.69	37.84	37.80	41.22	2.33	5.61	4.53	14.59	9.34	6.77
21	82.00	0.07	-4.19	20.04	26.83	32.07	43.15	/	/	6.00	4.28	4.53	10.42	/	/
22	93.00	0.06	-4.26	19.82	27.38	34.74	42.06	/	/	4.83	6.44	3.03	12.42	/	/
23	68.00	0.07	-6.27	20.07	26.64	32.99	39.57	41.05	/	3.33	6.44	4.36	11.26	8.34	/
24	65.00	0.11	-3.37	18.24	27.37	38.54	/	/	/	2.00	4.78	3.70	/	/	/
25	65.00	0.11	-2.89	18.30	26.55	34.59	/	/	/	4.17	1.61	5.86	/	/	/
26	66.00	0.07	-7.66	19.52	26.86	34.00	41.16	46.65	/	2.00	6.11	6.86	11.09	7.51	/
27	63.00	0.06	-10.08	19.03	27.61	33.56	38.92	38.39	46.86	7.83	5.78	5.20	11.42	9.51	5.94
28	75.00	0.05	-8.58	19.54	27.13	33.26	37.49	40.74	43.23	5.67	4.61	3.36	11.26	7.51	5.77
29	90.00	0.08	-2.39	19.23	27.15	32.91	/	/	/	5.33	3.94	6.86	/	/	/
30	89.00	0.08	-2.34	18.98	25.97	32.75	/	/	/	6.00	1.78	9.20	/	/	/
31	87.00	0.04	-8.45	18.60	27.42	31.06	37.77	39.77	42.26	7.50	4.28	4.20	11.76	8.84	6.77
32	85.00	0.05	-6.64	18.74	28.21	31.23	39.20	43.70	/	4.17	2.78	7.03	12.42	6.51	/
33	95.00	0.06	-4.39	20.29	28.63	34.71	44.67	/	/	6.33	5.78	6.36	11.42	/	/
34	90.00	0.06	-4.26	19.21	27.59	31.63	41.63	/	/	5.33	6.44	5.20	10.42	/	/
35	92.00	0.06	-3.70	19.63	28.47	31.86	35.33	/	/	0.83	5.44	7.53	13.26	/	/
36	106.00	0.05	-4.18	19.24	26.32	33.19	41.89	/	/	7.33	3.78	9.53	13.09	/	/
37	65.00	0.18	-1.06	19.66	28.07	/	/	/	/	4.50	8.61	/	/	/	/
38	62.00	0.09	-5.03	18.74	27.16	32.04	42.08	/	/	4.00	6.94	6.20	11.92	/	/
39	78.00	0.06	-6.17	20.25	27.73	35.01	40.43	40.54	/	1.17	4.94	5.86	14.09	8.68	/
40	94.00	0.08	-1.80	20.08	25.98	27.81	/	/	/	1.50	3.61	10.36	/	/	/
41	74.00	0.06	-6.20	19.17	26.32	33.26	36.75	40.29	/	1.33	3.78	6.20	12.92	10.18	/
42	85.00	0.05	-6.49	18.82	26.70	33.07	38.68	42.11	/	8.17	1.94	6.20	11.09	7.68	/
43	95.00	0.08	-2.09	20.27	26.45	32.42	/	/	/	1.67	3.78	7.20	/	/	/
44	91.00	0.08	-2.32	19.43	27.35	32.45	/	/	/	15.83	-0.06	6.36	/	/	/
45	58.00	0.08	-7.22	19.09	26.44	32.13	39.65	40.81	/	4.83	2.61	6.03	12.92	9.68	/
46	102.00	0.05	-4.49	18.48	27.20	33.98	40.88	/	/	2.67	9.11	4.53	12.76	/	/
47	87.00	0.05	-6.42	19.24	27.15	31.73	41.26	42.64	/	4.50	3.44	7.36	11.42	6.84	/
48	93.00	0.08	-2.77	19.81	27.39	39.73	/	/	/	10.17	4.11	6.03	/	/	/
49	86.00	0.05	-5.63	18.99	26.78	29.75	36.09	38.96	/	3.33	7.28	6.36	10.42	8.68	/
50	73.00	0.11	-2.69	20.53	27.39	38.55	/	/	/	2.83	1.78	6.03	/	/	/
51	75.00	0.06	-5.94	19.44	26.71	31.98	35.50	40.92	/	0.33	5.94	7.86	15.42	8.68	/
52	75.00	0.06	-6.35	19.43	26.76	33.87	38.49	41.08	/	1.67	4.94	2.86	10.92	9.34	/
53	94.00	0.08	-2.21	20.04	26.75	33.26	/	/	/	2.00	4.78	7.53	/	/	/
54	65.00	0.09	-4.64	19.68	28.09	32.98	41.35	/	/	1.67	7.28	5.86	11.76	/	/
55	91.00	0.12	-1.03	19.41	28.02	/	/	/	/	2.33	4.78	/	/	/	/
56	80.00	0.07	-4.60	19.55	27.74	33.70	43.51	/	/	3.17	0.78	7.03	11.76	/	/
57	73.00	0.08	-4.40	19.99	27.83	32.89	42.36	/	/	9.00	4.11	5.20	11.09	/	/
58	94.00	0.06	-4.06	20.05	26.89	33.52	41.97	/	/	4.67	3.11	6.03	11.76	/	/
59	78.00	0.06	-6.98	20.19	26.34	32.28	44.08	48.38	/	3.33	4.11	7.36	13.42	6.34	/
60	65.00	0.12	-2.56	19.65	27.03	34.20	/	/	/	0.67	7.11	6.20	/	/	/
61	61.00	0.19	-0.93	19.28	25.65	/	/	/	/	19.67	6.78	/	/	/	/
62	66.00	0.07	-6.61	19.54	28.47	32.78	38.92	40.12	/	5.33	4.44	3.53	12.59	9.51	/
63	72.00	0.10	-3.38	18.64	27.59	40.75	1.74	/	/	5.00	8.11	5.03	/	/	/
64	85.00	0.09	-2.19	20.13	26.59	32.83	1.74	/	/	5.00	-0.56	7.86	/	/	/
65	90.00	0.05	-5.65	19.89	27.50	31.14	36.62	42.37	/	5.67	5.28	6.53	11.76	7.51	/
66	93.00	0.06	-4.15	19.84	26.81	33.58	42.18	/	/	5.50	5.28	6.03	9.26	/	/
67	96.00	0.11	-1.07	18.94	28.14	/	/	/	/	6.33	3.61	/	/	/	/
68	73.00	0.10	-2.92	18.90	27.88	36.65	/	/	/	8.67	2.44	6.53	/	/	/
69	90.00	0.06	-4.22	19.21	26.11	32.79	41.31	/	/	1.67	1.61	6.53	12.26	/	/
70	88.00	0.04	-8.10	18.78	26.65	31.71	36.03	39.46	42.04	7.67	3.78	3.36	9.42	7.84	6.10
71	69.00	0.08	-4.96	18.92	28.36	32.93	42.44	/	/	8.00	5.78	6.03	11.42	/	/
72	90.00	0.08	-2.97	19.24	28.32	39.43	/	/	/	6.83	8.61	6.20	/	/	/
73	73.00	0.06	-5.90	18.92	26.99	31.66	34.98	38.01	/	7.67	5.28	7.36	13.92	9.51	/
74	64.00	0.18	-1.07	19.33	27.72	/	/	/	/	19.83	4.28	/	/	/	/
75	106.00	0.05	-4.21	19.22	27.86	34.16	40.16	/	/	4.67	8.28	6.03	15.09	/	/
76	66.00	0.11	-3.29	18.55	27.70	38.44	/	/	/	2.33	7.61	4.20	/	/	/
77	66.00	0.09	-4.30	19.90	26.10	34.10	39.89	/	/	2.00	4.78	5.53	12.92	/	/
78	72.00	0.06	-7.94	18.66	26.53	34.20	40.59	48.17	/	2.67	5.28	4.70	12.76	6.18	/
79	76.00	0.06	-6.76	19.72	27.12	34.32	41.52	43.42	/	0.33	8.28	6.36	12.76	9.01	/
80	65.00	0.09	-4.79	19.65	27.98	34.04	41.93	/	/	5.17	7.44	6.53	11.26	/	/
81	76.00	0.05	-8.28	19.70	27.05	34.19	38.33	39.01	42.63	4.50	4.78	2.70	8.76	6.68	6.10
82	61.00	0.13	-2.74	19.70	28.17	34.76	/	/	/	3.17	6.11	5.36	/	/	/
83	78.00	0.09	-4.05	18.45	26.41	47.92	/	/	/	3.17	-0.06	2.53	/	/	/
84	94.00	0.08	-2.20	20.08	28.09	31.94	/	/	/	1.83	5.61	8.20	/	/	/
85	103.00	0.05	-4.45	18.66	26.17	33.46	42.58	/	/	5.17	4.44	6.36	14.26	/	/
86	91.00	0.06	-4.23	19.41	27.20	33.24	41.11	/	/	4.17	5.94	3.86	12.09	/	/
87	63.00	0.06	-8.02	19.03	25.94	29.24	34.37	36.03	41.13	2.00	2.11	8.70	15.92	11.01	8.60
88	106.00	0.04	-6.22	19.22	27.82	33.38	39.36	43.28	/	4.67	4.61	5.03	10.42	6.51	/
89	91.00	0.06	-4.37	19.41	27.17	34.73	41.56	/	/	10.67	6.44	7.36	13.26	/	/
90	78.00	0.06	-6.47	20.20	26.26	32.10	43.74	43.98	/	1.83	3.78	6.86	13.09	10.51	/
91	79.00	0.07	-4.35	19.29	26.14	31.09	42.94	/	/	2.33	2.61	8.36	10.92	/	/
92	107.00	0.04	-6.71	19.32	26.44	33.34	42.07	49.09	/	3.17	3.61	5.36	12.92	6.18	/
93	86.00	0.05	-6.39	19.00	26.84	34.47	39.30	40.65	/	1.83	3.61	5.20	11.76	7.01	/
94	59.00	0.10	-5.05	19.45	27.28	34.90	41.26	/	/	5.67	3.11	4.20	12.59	/	/
95	79.00	0.07	-4.51	19.27	27.36	33.65	41.77	/	/	4.17	4.61	7.20	11.76	/	/
96	66.00	0.07	-7.13	19.51	26.59	33.46	40.42	43.91	/	1.33	3.94	6.20	10.59	8.01	/
97	73.00	0.15	-0.98	18.92	26.29	/	/	/	/	24.33	6.28	/	/	/	/
98	90.00	0.05	-6.58	19.92	27.15	32.38	43.01	46.60	/	1.00	4.11	5.86	11.92	9.68	/
99	65.00	0.07	-6.82	19.19	26.44	31.70	38.79	42.40	/	4.67	5.44	5.20	11.76	10.51	/
100	65.00	0.09	-4.64	19.68	28.09	32.98	41.35	/	/	1.67	7.28	5.86	11.76	/	/

Appendix Table B.12b Estimates and corresponding percentage bias of the demographic parameters computed by means of the ELEFAN I method and the EM algorithm in the sub-sampling of 1000 length measurements extracted from the European hake hypothetical population.

Sample size = 1000 length measurements																
Estimates																
EM algorithm																
	L_∞ (cm)	k (year-1)	t_0 (year)	mean 1 (cm)	mean 2 (cm)	mean 3 (cm)	mean 4 (cm)	mean 5 (cm)	mean 6 (cm)	SD 1 (cm)	SD 2 (cm)	SD 3 (cm)	SD 4 (cm)	SD 5 (cm)	SD 6 (cm)
1	78.99	0.12	-2.36	19.32	25.90	31.95	35.20	/	/	1.12	3.52	10.83	3.94	/	/
2	58.19	0.26	-1.58	19.39	28.06	34.96	38.19	44.29	/	1.19	13.17	5.39	-1.86	1.65	/
3	80.99	0.15	-1.89	19.52	27.75	35.06	39.26	/	/	1.22	5.34	13.01	6.37	/	/
4	60.99	0.17	-2.63	21.86	27.83	33.07	/	/	/	6.17	14.20	5.70	/	/	/
5	76.99	0.12	-2.65	20.66	26.82	32.49	35.41	41.84	/	3.56	14.62	-1.30	-0.49	-1.53	/
6	79.00	0.14	-1.97	19.31	27.10	34.07	37.99	/	/	1.18	4.87	9.10	3.37	/	/
7	57.49	0.22	-1.87	19.64	27.10	33.27	36.09	41.99	/	1.18	0.75	2.03	2.82	6.15	/
8	69.84	0.18	-1.81	19.12	27.22	34.21	37.95	/	/	1.06	0.78	1.95	4.54	/	/
9	62.96	0.15	-2.41	19.33	25.37	30.76	33.27	39.20	42.55	1.26	5.90	-2.51	8.17	4.11	3.15
10	93.01	0.11	-2.37	20.51	27.63	34.25	38.08	/	/	3.88	16.68	-0.02	-1.53	/	/
11	68.00	0.14	-2.51	20.52	26.75	32.35	35.08	41.24	/	3.10	14.77	-2.14	-6.07	-3.22	/
12	66.02	0.21	-1.65	19.32	28.06	35.35	39.13	45.88	/	1.23	5.84	7.17	0.97	-1.42	/
13	63.03	0.16	-2.53	21.13	27.26	32.68	35.18	41.06	44.33	7.70	17.55	0.03	-5.16	-1.08	4.81
14	87.02	0.09	-3.05	20.06	25.46	30.63	33.25	39.54	43.45	11.00	8.88	0.30	-4.11	8.18	7.76
15	84.96	0.13	-2.04	19.17	26.82	33.77	37.78	45.14	/	1.16	2.79	8.59	5.16	0.52	/
16	95.00	0.11	-2.41	21.49	28.81	35.60	39.58	/	/	5.81	5.85	10.99	2.46	/	/
17	89.99	0.10	-2.53	20.20	26.77	32.92	36.36	/	/	3.59	16.70	11.94	3.72	/	/
18	92.00	0.08	-3.17	19.50	24.64	29.61	32.10	/	/	0.91	5.52	12.84	2.39	/	/
19	65.00	0.31	-1.19	20.12	32.01	/	/	/	/	2.79	12.03	/	/	/	/
20	61.98	0.20	-1.83	19.17	26.90	33.40	36.60	/	/	1.16	16.57	7.77	1.04	/	/
21	77.96	0.14	-2.09	19.69	27.15	33.84	37.54	44.55	/	1.20	4.81	-0.94	7.78	8.23	/
22	94.00	0.11	-1.83	16.97	24.81	32.05	/	/	/	1.50	3.62	5.46	/	/	/
23	74.01	0.13	-2.30	19.21	25.82	31.83	34.97	41.54	/	1.03	3.65	7.54	0.71	4.06	/
24	85.00	0.10	-2.85	20.64	26.52	32.06	34.96	41.46	/	5.62	4.26	10.63	4.80	0.48	/
25	58.04	0.22	-1.82	19.17	26.74	33.01	35.92	41.92	/	1.26	3.45	5.80	8.37	7.85	/
26	86.97	0.11	-2.29	19.47	26.44	32.88	36.52	43.63	/	1.52	3.59	9.55	5.84	0.73	/
27	86.00	0.08	-3.17	19.59	24.69	29.59	31.99	38.09	/	2.68	19.89	1.03	-5.70	-2.26	/
28	75.00	0.13	-2.30	19.30	25.95	31.99	35.17	41.78	/	1.01	5.67	1.45	7.77	7.72	/
29	75.03	0.13	-2.35	19.31	25.83	31.78	34.90	41.47	/	1.18	11.60	3.71	-2.77	4.46	/
30	64.98	0.18	-1.97	19.46	26.87	33.24	36.45	/	/	1.00	19.23	3.79	-2.61	/	/
31	91.00	0.20	-1.17	19.00	31.98	/	/	/	/	1.31	11.73	/	/	/	/
32	80.01	0.15	-1.87	19.36	27.61	34.92	39.11	/	/	1.26	1.25	10.60	-0.07	/	/
33	94.00	0.10	-2.25	19.75	27.03	33.79	37.76	/	/	3.79	3.59	11.54	2.04	/	/
34	78.02	0.15	-1.95	19.41	27.28	34.28	38.20	45.38	/	1.86	4.14	0.35	6.52	3.47	/
35	65.00	0.20	-1.79	19.58	27.70	34.54	/	/	/	0.83	14.66	6.48	/	/	/
36	66.06	0.17	-2.09	19.39	26.44	32.61	35.71	42.09	/	1.22	10.77	1.51	1.66	4.80	/
37	93.00	0.10	-2.37	20.22	27.27	33.84	37.63	/	/	4.31	5.20	10.97	3.77	/	/
38	90.00	0.11	-2.18	19.15	26.41	33.13	37.02	/	/	1.14	2.08	10.32	3.78	/	/
39	88.02	0.09	-2.87	19.64	25.30	30.69	33.50	39.95	44.01	13.93	6.39	-3.49	-5.75	-3.50	4.09
40	68.98	0.20	-1.65	19.10	27.91	35.34	39.32	/	/	1.19	3.55	11.13	7.87	/	/
41	72.07	0.16	-1.85	18.97	26.94	33.89	37.67	44.63	/	1.20	5.82	-0.91	5.56	7.10	/
42	76.00	0.14	-2.14	19.63	26.85	33.34	36.86	43.72	/	1.24	14.40	4.17	-0.12	-0.62	/
43	64.95	0.18	-2.12	20.79	28.02	34.24	37.32	/	/	4.17	13.81	11.76	3.29	/	/
44	60.98	0.24	-1.59	19.50	28.32	35.44	/	/	/	0.94	14.09	6.91	/	/	/
45	94.00	0.13	-1.34	15.20	24.78	33.39	/	/	/	1.83	5.62	5.98	/	/	/
46	91.00	0.10	-2.51	19.98	26.54	32.70	36.15	/	/	3.57	18.23	-1.08	-3.16	/	/
47	62.94	0.14	-2.50	19.10	24.88	30.09	32.48	38.34	41.65	1.04	2.67	3.68	9.12	4.28	7.32
48	91.00	0.12	-1.94	19.26	27.42	34.84	39.28	/	/	1.20	5.74	12.96	8.21	/	/
49	79.01	0.14	-2.03	19.33	26.91	33.71	37.52	/	/	1.12	2.95	6.98	2.98	/	/
50	85.99	0.10	-2.57	19.31	25.49	31.29	34.42	41.13	/	1.17	3.53	8.80	-0.29	-3.50	/
51	78.99	0.15	-1.93	19.40	27.41	34.52	38.55	/	/	1.27	4.36	13.41	4.48	/	/
52	66.00	0.19	-1.85	19.36	27.22	33.94	37.39	43.96	/	1.25	3.82	8.74	1.35	-2.47	/
53	62.94	0.14	-2.50	19.10	24.88	30.09	32.48	38.34	41.65	1.04	2.67	3.68	9.12	4.28	7.32
54	80.99	0.15	-1.89	19.52	27.75	35.06	39.26	/	/	1.22	5.34	13.01	6.37	/	/
55	76.99	0.12	-2.65	20.66	26.82	32.49	35.41	41.84	/	3.56	14.62	-1.30	-0.49	-1.53	/
56	57.49	0.22	-1.87	19.64	27.10	33.27	36.09	41.99	/	1.18	0.75	2.03	2.82	6.15	/
57	62.96	0.15	-2.41	19.33	25.37	30.76	33.27	39.20	42.55	1.26	5.90	-2.51	8.17	4.11	3.15
58	68.00	0.14	-2.51	20.52	26.75	32.35	35.08	41.24	/	3.10	14.77	-2.14	-6.07	-3.22	/
59	63.03	0.16	-2.53	21.13	27.26	32.68	35.18	41.06	44.33	7.70	17.55	0.03	-5.16	-1.08	4.81
60	84.96	0.13	-2.04	19.17	26.82	33.77	37.78	45.14	/	1.16	2.79	8.59	5.16	0.52	/
61	89.99	0.10	-2.53	20.20	26.77	32.92	36.36	/	/	3.59	16.70	11.94	3.72	/	/
62	65.00	0.31	-1.19	20.12	32.01	/	/	/	/	2.79	12.03	/	/	/	/
63	77.96	0.14	-2.09	19.69	27.15	33.84	37.54	44.55	/	1.20	4.81	-0.94	7.78	8.23	/
64	74.01	0.13	-2.30	19.21	25.82	31.83	34.97	41.54	/	1.03	3.65	7.54	0.71	4.06	/
65	58.04	0.22	-1.82	19.17	26.74	33.01	35.92	41.92	/	1.26	3.45	5.80	8.37	7.85	/
66	86.00	0.08	-3.17	19.59	24.69	29.59	31.99	38.09	/	2.68	19.89	1.03	-5.70	-2.26	/
67	75.03	0.13	-2.35	19.31	25.83	31.78	34.90	41.47	/	1.18	11.60	3.71	-2.77	4.46	/
68	91.00	0.20	-1.17	19.00	31.98	/	/	/	/	1.31	11.73	/	/	/	/
69	94.00	0.10	-2.25	19.75	27.03	33.79	37.76	/	/	3.79	3.59	11.54	2.04	/	/
70	65.00	0.20	-1.79	19.58	27.70	34.54	/	/	/	0.83	14.66	6.48	/	/	/
71	93.00	0.10	-2.37	20.22	27.27	33.84	37.63	/	/	4.31	5.20	10.97	3.77	/	/
72	88.02	0.09	-2.87	19.64	25.30	30.69	33.50	39.95	44.01	13.93	6.39	-3.49	-5.75	-3.50	4.09
73	72.07	0.16	-1.85	18.97	26.94	33.89	37.67	44.63	/	1.20	5.82	-0.91	5.56	7.10	/
74	64.95	0.18	-2.12	20.79	28.02	34.24	37.32	/	/	4.17	13.81	11.76	3.29	/	/
75	94.00	0.13	-1.34	15.20	24.78	33.39	/	/	/	1.83	5.62	5.98	/	/	/
76	62.94	0.14	-2.50	19.10	24.88	30.09	32.48	38.34	41.65	1.04	2.67	3.68	9.12	4.28	7.32
77	79.01	0.14	-2.03	19.33	26.91	33.71	37.52	/	/	1.12	2.95	6.98	2.98	/	/
78	78.99	0.15	-1.93	19.40	27.41	34.52	38.55	/	/	1.27	4.36	13.41	4.48	/	/
79	62.94	0.14	-2.50	19.10	24.88	30.09	32.48	38.34	41.65	1.04	2.67	3.68	9.12	4.28	7.32
80	79.00	0.14	-1.97	19.31	27.10	34.07	37.99	/	/	1.18	4.87	9.10	3.37	/	/
81	62.96	0.15	-2.41	19.33	25.37	30.76	33.27	39.20	42.55	1.26	5.90	-2.51	8.17	4.11	3.15
82	63.03	0.16	-2.53	21.13	27.26	32.68	35.18	41.06	44.33	7.70	17.55	0.03	-5.16	-1.08	4.81
83	89.99	0.10	-2.53	20.20	26.77	32.92	36.36	/	/	3.59	16.70	11.94	3.72	/	/
84	77.96	0.14	-2.09	19.69	27.15	33.84	37.54	44.55	/	1.20	4.81	-0.94	7.78	8.23	/
85	58.04	0.22	-1.82	19.17	26.74	33.01	35.92	41.92	/	1.26	3.45	5.80	8.37	7.85	/
86	75.03	0.13	-2.35	19.31	25.83	31.78	34.90	41.47	/	1.18	11.60	3.71	-2.77	4.46	/
87	80.01	0.15	-1.87	19.36	27.61	34.92	39.11	/	/	1.26	1.25	10.60	-0.07	/	/
88	65.00	0.20	-1.79	19.58	27.70	34.54	/	/	/	0.83	14.66	6.48	/	/	/
89	90.00	0.11	-2.18	19.15	26.41	33.13	37.02	/	/	1.14	2.08	10.32	3.78	/	/
90	72.07	0.16	-1.85	18.97	26.94	33.89	37.67	44.63	/	1.20	5.82	-0.91	5.56	7.10	/
91	60.98	0.24	-1.59	19.50	28.32	35.44	/	/	/	0.94	14.09	6.91	/	/	/
92	62.94	0.14	-2.50	19.10	24.88	30.09	32.48	38.34	41.65	1.04	2.67	3.68	9.12	4.28	7.32
93	85.99	0.10	-2.57	19.31	25.49	31.29	34.42	41.13	/	1.17	3.53	8.80	-0.29	-3.50	/
94	62.94	0.14	-2.50	19.10	24.88	30.09	32.48	38.34	41.65	1.04	2.67	3.68	9.12	4.28	7.32
95	65.00	0.31	-1.19	20.12	32.01	/	/	/	/	2.79	12.03	/	/	/	/
96	77.96	0.14	-2.09	19.69	27.15	33.84	37.54	44.55	/	1.20	4.81	-0.94	7.78	8.23	/
97	74.01	0.13	-2.30	19.21	25.82	31.83	34.97	41.54	/	1.03	3.65	7.54	0.71	4.06	/
98	58.04	0.22	-1.82	19.17	26.74	33.01	35.92	41.92	/	1.26	3.45	5.80	8.37	7.85	/
99	91.00	0.20	-1.17	19.00	31.98	/	/	/	/	1.31	11.73	/	/	/	/
100	94.00	0.10	-2.25	19.75	27.03	33.79	37.76	/	/	3.79	3.59	11.54	2.04	/	/

Appendix Table B.12c Estimates and corresponding percentage bias of the demographic parameters computed by means of the ELEFAN I method and the EM algorithm in the sub-sampling of 1000 length measurements extracted from the European hake hypothetical population.

Sample size = 1000 length measurements															
% Bias															
ELEFAN I method															
	L_∞	*k*	t_0	*mean 1*	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*SD 1*	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*
1	67.67	-67.32	1073.84	-0.71	-5.31	1.26	15.44	/	/	235.65	238.20	528.21	-562.89	/	/
2	24.96	-54.25	952.04	-0.42	4.60	-5.35	-37.20	/	/	62.04	152.98	576.05	329.01	/	/
3	34.45	-41.18	635.66	3.80	-5.61	21.74	/	/	/	108.33	99.71	73.68	/	/	/
4	-8.26	-47.71	2362.07	-1.41	2.22	2.27	-0.12	2.17	/	108.33	366.03	169.37	428.12	-554.54	/
5	67.67	-73.86	1527.88	-0.90	-4.02	2.56	-12.49	-13.04	/	177.78	152.98	-237.31	31.71	-184.85	/
6	28.12	-54.25	1085.51	2.02	2.71	1.12	7.60	/	/	166.20	302.12	623.90	-166.49	/	/
7	-3.51	-15.03	592.21	1.80	1.69	1.57	/	/	/	339.81	493.87	480.36	/	/	/
8	62.92	-54.25	673.99	0.45	-2.33	25.58	/	/	/	941.67	152.98	623.90	/	/	/
9	47.11	-60.78	1046.72	2.24	-3.23	1.43	13.57	/	/	432.41	184.93	288.98	229.91	/	/
10	10.72	-28.10	565.58	1.53	2.43	1.12	/	/	/	-76.85	280.81	623.90	/	/	/
11	9.14	-47.71	1233.07	-2.67	-3.28	-1.62	14.88	/	/	62.04	142.32	336.83	1518.22	/	/
12	21.80	-60.78	1612.44	2.93	6.92	0.37	-2.29	-12.63	/	200.93	355.38	25.84	923.62	-20.54	/
13	62.92	-54.25	654.78	0.72	0.59	21.49	/	/	/	1254.17	323.42	360.75	/	/	/
14	24.96	-54.25	1082.68	-0.57	-1.99	-1.52	0.19	/	/	-7.41	259.51	623.90	428.12	/	/
15	20.22	-60.78	1557.69	1.75	-0.08	0.12	-17.68	-14.55	/	38.89	248.85	265.06	824.52	349.15	/
16	59.76	-28.10	124.64	2.85	-9.55	/	/	/	/	501.85	238.20	/	/	/	/
17	5.98	-41.18	1072.15	4.26	-4.22	5.68	-6.82	/	/	27.31	-6.82	456.44	2013.73	/	/
18	69.25	-73.86	1714.75	-0.25	8.57	-0.05	3.66	1.67	/	432.41	291.46	456.44	-761.09	-472.38	/
19	39.20	-60.78	1105.24	-3.25	2.27	3.12	-11.38	/	/	247.22	110.36	432.52	1220.92	/	/
20	-0.35	-60.78	2329.40	-1.84	3.23	-0.66	-26.37	-19.81	-23.20	62.04	291.46	241.14	1914.63	20.54	-47.02
21	29.71	-54.25	1032.80	3.36	-2.41	-2.58	10.66	/	/	316.67	206.24	241.14	-562.89	/	/
22	47.11	-60.78	1051.42	2.21	1.28	5.61	3.04	/	/	235.65	344.73	25.84	626.32	/	/
23	7.56	-54.25	1595.89	3.52	-3.67	0.26	-14.32	-12.91	/	131.48	344.73	217.22	-67.39	-225.92	/
24	2.82	-28.10	810.28	-5.92	1.19	17.29	/	/	/	38.89	238.20	121.53	/	/	/
25	2.82	-28.10	679.86	-5.62	-4.25	5.16	/	/	/	189.35	35.79	432.52	/	/	/
26	4.40	-54.25	1969.87	0.65	-2.18	3.34	-3.22	-1.03	/	38.89	323.42	576.05	-166.49	-431.31	/
27	-0.35	-60.78	2623.07	-1.85	2.79	1.99	-18.83	-18.57	-12.69	443.98	302.12	336.83	31.71	61.62	-70.35
28	18.63	-67.32	2219.25	0.75	-0.41	1.09	-28.79	-13.58	-19.45	293.52	227.55	73.68	-67.39	-431.31	-75.01
29	42.36	-47.71	544.88	-0.82	-0.27	-0.01	/	/	/	270.37	184.93	576.05	/	/	/
30	40.78	-47.71	532.74	-2.10	-8.10	-0.49	/	/	/	316.67	46.45	910.97	/	/	/
31	37.61	-73.86	2184.96	-4.10	1.54	-5.68	-26.84	-15.64	-21.27	420.83	206.24	193.29	229.91	-102.69	-47.02
32	34.45	-67.32	1695.32	-3.37	6.76	-5.17	-16.90	-7.31	/	189.35	110.36	599.97	626.32	-677.77	/
33	50.27	-60.78	1085.79	4.62	9.58	5.51	21.27	/	/	339.81	302.12	504.28	31.71	/	/
34	42.36	-60.78	1051.85	-0.95	2.67	-3.93	0.09	/	/	270.37	344.73	336.83	-562.89	/	/
35	45.52	-60.78	899.69	1.25	8.49	-3.23	-43.84	/	/	-42.13	280.81	671.74	1121.82	/	/
36	67.67	-67.32	1029.72	-0.75	-5.76	0.87	1.89	/	/	409.26	174.28	958.81	1022.72	/	/
37	2.82	17.65	187.26	1.37	5.88	/	/	/	/	212.50	483.22	/	/	/	/
38	-1.93	-41.18	1260.08	-3.33	-0.21	-2.67	3.17	/	/	177.78	376.69	480.36	329.01	/	/
39	23.38	-60.78	1568.47	4.42	3.62	6.46	-8.27	-14.01	/	-18.98	248.85	432.52	1617.32	-143.77	/
40	48.69	-47.71	387.50	3.57	-8.03	-15.65	/	/	/	4.17	163.63	1078.42	/	/	/
41	17.05	-60.78	1576.59	-1.11	-5.76	1.08	-33.93	-14.53	/	-7.41	174.28	480.36	923.62	225.92	/
42	34.45	-67.32	1653.67	-2.93	-3.28	0.48	-20.51	-10.66	/	467.13	57.10	480.36	-166.49	-390.23	/
43	50.27	-47.71	465.36	4.56	-4.91	-1.51	/	/	/	15.74	174.28	623.90	/	/	/
44	43.94	-47.71	526.93	0.19	1.05	-1.40	/	/	/	999.54	-70.74	504.28	/	/	/
45	-8.26	-47.71	1851.22	-1.52	-4.97	-2.39	-13.72	-13.43	/	235.65	99.71	456.44	923.62	102.69	/
46	61.34	-67.32	1113.16	-4.68	0.06	3.30	-5.17	/	/	85.19	515.18	241.14	824.52	/	/
47	37.61	-67.32	1635.03	-0.79	-0.27	-3.62	-2.49	-9.54	/	212.50	152.98	647.82	31.71	-595.62	/
48	47.11	-47.71	647.62	2.19	1.33	20.94	/	/	/	606.02	195.59	456.44	/	/	/
49	36.03	-67.32	1422.42	-2.07	-2.73	-9.70	-38.55	-17.36	/	131.48	397.99	504.28	-562.89	-143.77	/
50	15.47	-28.10	627.95	5.86	1.34	17.32	/	/	/	96.76	46.45	456.44	/	/	/
51	18.63	-60.78	1504.18	0.27	-3.18	-2.85	-42.65	-13.19	/	-76.85	312.77	719.59	2410.13	-143.77	/
52	18.63	-60.78	1617.11	0.21	-2.88	2.95	-21.84	-12.86	/	15.74	248.85	1.91	-265.59	20.54	/
53	48.69	-47.71	496.38	3.37	-2.90	1.06	/	/	/	38.89	238.20	671.74	/	/	/
54	2.82	-41.18	1154.72	1.48	6.00	0.21	-1.87	/	/	15.74	397.99	432.52	229.91	/	/
55	43.94	-21.57	177.25	0.10	5.52	/	/	/	/	62.04	238.20	/	/	/	/
56	26.54	-54.25	1144.26	0.83	3.66	2.43	13.18	/	/	119.91	-17.47	599.97	229.91	/	/
57	15.47	-47.71	1090.05	3.08	4.28	-0.06	5.13	/	/	525.00	195.59	336.83	-166.49	/	/
58	48.69	-60.78	997.57	3.42	-2.00	1.86	2.45	/	/	224.07	131.67	456.44	229.91	/	/
59	23.38	-60.78	1786.77	4.14	-5.64	-1.93	17.13	2.63	/	131.48	195.59	647.82	1220.92	-718.85	/
60	2.82	-21.57	591.73	1.35	-1.05	3.97	/	/	/	-53.70	387.34	480.36	/	/	/
61	-3.51	24.18	150.61	-0.55	-10.26	/	/	/	/	1265.74	366.03	/	/	/	/
62	4.40	-54.25	1686.95	0.79	8.53	-0.39	-18.80	-14.89	/	270.37	216.89	97.60	725.42	61.62	/
63	13.89	-34.64	814.06	-3.89	2.65	24.07	/	/	/	247.22	451.26	312.91	/	/	/
64	34.45	-41.18	492.07	3.80	-4.02	-0.23	/	/	/	247.22	-102.69	719.59	/	/	/
65	42.36	-67.32	1428.26	2.60	2.03	-5.43	-34.88	-10.12	/	293.52	270.16	528.21	229.91	-431.31	/
66	47.11	-60.78	1022.58	2.30	-2.50	2.06	3.90	/	/	281.94	270.16	456.44	-1256.60	/	/
67	51.85	-28.10	188.78	-2.30	6.30	/	/	/	/	339.81	163.63	/	/	/	/
68	15.47	-34.64	688.72	-2.51	4.60	11.49	/	/	/	501.85	89.06	528.21	/	/	/
69	42.36	-60.78	1040.82	-0.93	-7.21	-0.36	-2.17	/	/	15.74	35.79	528.21	527.22	/	/
70	39.20	-73.86	2089.03	-3.13	-3.62	-3.67	-38.98	-16.30	-21.67	432.41	174.28	73.68	-1157.50	-349.15	-65.68
71	9.14	-47.71	1240.07	-2.44	7.79	0.06	5.71	/	/	455.56	302.12	456.44	31.71	/	/
72	42.36	-47.71	702.63	-0.79	7.49	20.01	/	/	/	374.54	483.22	480.36	/	/	/
73	15.47	-60.78	1494.90	-2.41	-1.36	-3.85	-46.31	-19.37	/	432.41	270.16	647.82	1518.22	61.62	/
74	1.23	17.65	188.48	-0.30	3.53	/	/	/	/	1277.31	206.24	/	/	/	/
75	67.67	-67.32	1038.71	-0.89	4.47	3.85	-10.17	/	/	224.07	461.91	456.44	2211.93	/	/
76	4.40	-28.10	787.97	-4.33	3.37	16.98	/	/	/	62.04	419.30	193.29	/	/	/
77	4.40	-41.18	1062.93	2.66	-7.27	3.67	-12.07	/	/	38.89	238.20	384.67	923.62	/	/
78	13.89	-60.78	2046.45	-3.77	-4.36	3.96	-7.19	2.18	/	85.19	270.16	265.06	824.52	-759.92	/
79	20.22	-60.78	1726.98	1.69	-0.46	4.31	-0.73	-7.89	/	-76.85	461.91	504.28	824.52	-61.62	/
80	2.82	-41.18	1194.90	1.36	5.25	3.48	2.19	/	/	258.80	408.65	528.21	-67.39	/	/
81	20.22	-67.32	2138.63	1.59	-0.94	3.93	-22.91	-17.25	-20.57	212.50	238.20	-22.01	-1553.90	-636.69	-65.68
82	-3.51	-15.03	641.14	1.61	6.52	5.68	/	/	/	119.91	323.42	360.75	/	/	/
83	23.38	-41.18	994.82	-4.86	-5.16	46.08	/	/	/	119.91	-70.74	-45.93	/	/	/
84	48.69	-47.71	495.28	3.57	5.97	-2.99	/	/	/	27.31	291.46	767.43	/	/	/
85	62.92	-67.32	1101.72	-3.75	-6.81	1.68	6.70	/	/	258.80	216.89	504.28	1716.42	/	/
86	43.94	-60.78	1042.24	0.12	0.05	1.00	-3.58	/	/	189.35	312.77	145.45	428.12	/	/
87	-0.35	-60.78	2067.41	-1.85	-8.30	-11.26	-50.54	-23.57	-23.37	38.89	67.75	839.20	2707.43	431.31	4.29
88	67.67	-73.86	1581.47	-0.88	4.20	1.45	-15.76	-8.19	/	224.07	227.55	312.91	-562.89	-677.77	/
89	43.94	-60.78	1081.26	0.09	-0.11	5.59	-0.38	/	/	640.74	344.73	647.82	1121.82	/	/
90	23.38	-60.78	1648.93	4.19	-6.20	-2.48	14.80	-6.69	/	27.31	174.28	576.05	1022.72	308.08	/
91	24.96	-54.25	1074.40	-0.53	-6.99	-5.57	9.18	/	/	62.04	99.71	791.35	-265.59	/	/
92	69.25	-73.86	1713.24	-0.34	-5.01	1.32	3.15	4.13	/	119.91	163.63	360.75	923.62	-759.92	/
93	36.03	-67.32	1627.52	-1.99	-2.30	4.80	-16.20	-13.77	/	27.31	163.63	336.83	229.91	-554.54	/
94	-6.68	-34.64	1264.97	0.30	0.59	6.11	-2.49	/	/	293.52	131.67	193.29	725.42	/	/
95	24.96	-54.25	1120.19	-0.62	1.15	2.27	1.03	/	/	189.35	227.55	623.90	229.91	/	/
96	4.40	-54.25	1827.70	0.60	-4.00	1.69	-8.38	-6.86	/	-7.41	184.93	480.36	-463.79	-308.08	/
97	15.47	-1.96	164.94	-2.42	-6.01	/	/	/	/	1589.81	334.08	/	/	/	/
98	42.36	-67.32	1679.69	2.74	-0.29	-1.62	9.68	-1.14	/	-30.56	195.59	432.52	329.01	102.69	/
99	2.82	-54.25	1744.29	-1.03	-4.96	-3.71	-19.75	-10.05	/	224.07	280.81	336.83	229.91	308.08	/
100	2.82	-41.18	1154.72	1.48	6.00	0.21	-1.87	/	/	15.74	397.99	432.52	229.91	/	/

Appendix Table B.12d Estimates and corresponding percentage bias of the demographic parameters computed by means of the ELEFAN I method and the EM algorithm in the sub-sampling of 1000 length measurements extracted from the European hake hypothetical population.

Sample size = 1000 length measurements																
% Bias																
EM algorithm																
	L_∞	*k*	t_0	*mean 1*	*mean 2*	*mean 3*	*mean 4*	*mean 5*	*mean 6*	*SD 1*	*SD 2*	*SD 3*	*SD 4*	*SD 5*	*SD 6*
1	24.95	-22.28	537.68	-0.34	-2.19	-2.85	-2.39	/	/	-22.28	102.16	199.97	22.19	/	/
2	-7.95	67.68	327.00	0.02	2.24	6.22	0.31	-6.05	/	-17.47	503.33	129.52	9.58	17.04	/
3	28.10	-4.73	411.42	0.68	1.60	6.51	1.27	/	/	-15.62	178.00	228.14	27.47	/	/
4	-3.53	10.36	610.57	12.76	1.77	0.53	/	/	/	328.81	546.16	133.53	/	/	/
5	21.79	-22.94	616.25	6.56	-0.31	-1.22	-2.20	-11.24	/	147.49	563.60	42.93	12.57	4.80	/
6	24.95	-7.18	433.48	-0.40	0.27	3.52	0.12	/	/	-18.31	158.59	177.62	20.96	/	/
7	-9.06	45.90	405.98	1.28	0.27	1.11	-1.59	-10.92	/	-18.20	-12.69	86.12	19.75	34.29	/
8	10.47	15.46	389.30	-1.41	0.51	3.95	0.09	/	/	-26.59	-11.70	84.98	23.50	/	/
9	-0.41	-0.69	552.18	-0.33	-3.29	-6.44	-4.13	-16.85	-20.72	-12.41	201.01	27.37	31.39	26.46	-13.26
10	47.11	-31.31	540.65	5.77	1.36	4.07	0.21	/	/	169.70	649.20	59.53	10.30	/	/
11	7.56	-6.35	577.65	5.85	-0.45	-1.64	-2.50	-12.52	/	115.61	569.85	32.11	0.42	-1.69	/
12	4.43	37.36	345.30	-0.34	2.25	7.37	1.16	-2.68	/	-14.33	198.55	152.67	15.74	5.23	/
13	-0.30	5.50	583.52	8.95	0.60	-0.64	-2.41	-12.90	-17.39	434.92	685.56	60.24	2.39	6.51	30.70
14	37.64	-43.81	723.80	3.44	-3.09	-6.82	-4.15	-16.12	-19.04	663.76	325.26	63.63	4.68	42.10	108.38
15	34.39	-17.96	450.57	-1.14	-0.31	2.64	-0.06	-4.24	/	-19.71	71.86	170.95	24.86	12.69	/
16	50.27	-30.32	550.09	10.82	3.78	8.14	1.56	/	/	303.19	199.32	202.02	18.97	/	/
17	42.35	-34.23	582.75	4.18	-0.41	0.07	-1.35	/	/	149.04	650.18	214.38	21.73	/	/
18	45.52	-50.86	756.21	0.55	-4.79	-9.88	-5.18	/	/	-37.08	185.22	226.00	18.81	/	/
19	2.82	103.22	221.96	3.77	10.33	/	/	/	/	93.77	455.89	/	/	/	/
20	-1.97	32.11	394.90	-1.12	-0.15	1.52	-1.12	/	/	-19.56	644.92	160.34	15.89	/	/
21	23.32	-9.13	466.00	1.57	0.37	2.83	-0.28	-5.49	/	-16.41	155.95	47.64	30.55	42.30	/
22	48.69	-28.76	393.65	-12.49	-4.43	-2.54	/	/	/	4.17	106.47	130.47	/	/	/
23	17.06	-14.45	520.46	-0.94	-2.36	-3.22	-2.59	-11.87	/	-28.39	107.59	157.37	15.17	26.29	/
24	34.45	-36.14	669.36	6.44	-0.92	-2.52	-2.61	-12.05	/	290.32	133.22	197.41	24.07	12.53	/
25	-8.19	43.82	392.41	-1.14	-0.48	0.33	-1.74	-11.07	/	-12.71	99.28	134.92	31.83	40.83	/
26	37.57	-27.63	518.79	0.44	-1.09	-0.05	-1.20	-7.45	/	5.23	105.26	183.38	26.34	13.48	/
27	36.03	-46.65	756.00	1.05	-4.68	-9.94	-5.29	-19.19	/	85.79	782.94	73.15	1.23	2.00	/
28	18.63	-15.54	522.45	-0.44	-2.10	-2.74	-2.42	-11.36	/	-29.78	191.49	78.61	30.54	40.32	/
29	18.68	-17.15	534.42	-0.42	-2.33	-3.35	-2.66	-12.03	/	-18.03	438.22	107.76	7.59	27.80	/
30	2.79	17.87	433.57	0.38	-0.21	1.04	-1.26	/	/	-30.68	755.27	108.80	7.95	/	/
31	43.94	31.11	215.60	-1.99	10.28	/	/	/	/	-8.82	443.53	/	/	/	/
32	26.56	-3.10	405.14	-0.13	1.31	6.10	1.13	/	/	-12.40	8.03	196.97	13.48	/	/
33	48.69	-31.47	508.00	1.86	0.13	2.70	-0.08	/	/	162.93	105.18	209.13	18.06	/	/
34	23.42	-4.37	428.30	0.09	0.63	4.15	0.32	-3.74	/	29.43	128.13	64.36	27.82	24.00	/
35	2.81	30.61	384.94	1.00	1.50	4.95	/	/	/	-42.45	565.30	143.62	/	/	/
36	4.48	8.86	464.01	0.02	-1.08	-0.86	-1.93	-10.72	/	-15.47	403.74	79.34	17.24	29.13	/
37	47.10	-32.29	539.58	4.28	0.62	2.83	-0.20	/	/	199.37	172.06	201.82	21.83	/	/
38	42.36	-28.16	488.19	-1.25	-1.14	0.69	-0.75	/	/	-20.86	42.34	193.44	21.84	/	/
39	39.23	-42.41	674.47	1.30	-3.43	-6.65	-3.93	-15.24	-18.00	867.26	221.61	14.61	1.11	-2.78	11.68
40	9.12	28.68	345.11	-1.48	1.92	7.34	1.33	/	/	-17.22	103.30	203.86	30.75	/	/
41	14.00	7.83	400.50	-2.14	-0.06	3.00	-0.16	-5.33	/	-16.67	197.77	47.99	25.73	37.95	/
42	20.21	-8.88	479.31	1.24	-0.24	1.34	-0.89	-7.25	/	-14.01	554.48	113.83	13.37	8.29	/
43	2.74	18.76	473.87	7.22	2.15	4.05	-0.48	/	/	189.25	529.84	211.98	20.78	/	/
44	-3.55	58.60	329.06	0.54	2.78	7.66	/	/	/	-34.73	541.61	149.22	/	/	/
45	48.69	-14.23	263.33	-21.59	-4.48	1.48	/	/	/	27.31	189.59	137.22	/	/	/
46	43.94	-35.50	578.97	3.05	-0.87	-0.60	-1.53	/	/	147.77	713.68	45.85	6.74	/	/
47	-0.44	-5.62	576.80	-1.50	-4.28	-8.43	-4.84	-18.68	-22.40	-27.85	66.92	107.40	33.46	27.10	96.75
48	43.94	-19.97	424.99	-0.66	0.92	5.85	1.29	/	/	-16.52	194.38	227.49	31.48	/	/
49	24.98	-9.87	449.84	-0.31	-0.13	2.45	-0.30	/	/	-22.53	78.59	150.18	20.10	/	/
50	36.01	-35.25	593.82	-0.41	-3.04	-4.83	-3.09	-12.76	/	-18.54	102.77	173.65	12.99	-2.78	/
51	24.94	-4.32	420.43	0.07	0.90	4.90	0.63	/	/	-11.66	136.97	233.41	23.37	/	/
52	4.40	22.49	400.84	-0.13	0.52	3.13	-0.41	-6.74	/	-13.42	114.69	172.96	16.55	1.19	/
53	-0.44	-5.62	576.80	-1.50	-4.28	-8.43	-4.84	-18.68	-22.40	-27.85	66.92	107.40	33.46	27.10	96.75
54	28.10	-4.73	411.42	0.68	1.60	6.51	1.27	/	/	-15.62	178.00	228.14	27.47	/	/
55	21.79	-22.94	616.25	6.56	-0.31	-1.22	-2.20	-11.24	/	147.49	563.60	42.93	12.57	4.80	/
56	-9.06	45.90	405.98	1.28	0.27	1.11	-1.59	-10.92	/	-18.20	-12.69	86.12	19.75	34.29	/
57	-0.41	-0.69	552.18	-0.33	-3.29	-6.44	-4.13	-16.85	-20.72	-12.41	201.01	27.37	31.39	26.46	-13.26
58	7.56	-6.35	577.65	5.85	-0.45	-1.64	-2.50	-12.52	/	115.61	569.85	32.11	0.42	-1.69	/
59	-0.30	5.50	583.52	8.95	0.60	-0.64	-2.41	-12.90	-17.39	434.92	685.56	60.24	2.39	6.51	30.70
60	34.39	-17.96	450.57	-1.14	-0.31	2.64	-0.06	-4.24	/	-19.71	71.86	170.95	24.86	12.69	/
61	42.35	-34.23	582.75	4.18	-0.41	0.07	-1.35	/	/	149.04	650.18	214.38	21.73	/	/
62	2.82	103.22	221.96	3.77	10.33	/	/	/	/	93.77	455.89	/	/	/	/
63	23.32	-9.13	466.00	1.57	0.37	2.83	-0.28	-5.49	/	-16.41	155.95	47.64	30.55	42.30	/
64	17.06	-14.45	520.46	-0.94	-2.36	-3.22	-2.59	-11.87	/	-28.39	107.59	157.37	15.17	26.29	/
65	-8.19	43.82	392.41	-1.14	-0.48	0.33	-1.74	-11.07	/	-12.71	99.28	134.92	31.83	40.83	/
66	36.03	-46.65	756.00	1.05	-4.68	-9.94	-5.29	-19.19	/	85.79	782.94	73.15	1.23	2.00	/
67	18.68	-17.15	534.42	-0.42	-2.33	-3.35	-2.66	-12.03	/	-18.03	438.22	107.76	7.59	27.80	/
68	43.94	31.11	215.60	-1.99	10.28	/	/	/	/	-8.82	443.53	/	/	/	/
69	48.69	-31.47	508.00	1.86	0.13	2.70	-0.08	/	/	162.93	105.18	209.13	18.06	/	/
70	2.81	30.61	384.94	1.00	1.50	4.95	/	/	/	-42.45	565.30	143.62	/	/	/
71	47.10	-32.29	539.58	4.28	0.62	2.83	-0.20	/	/	199.37	172.06	201.82	21.83	/	/
72	39.23	-42.41	674.47	1.30	-3.43	-6.65	-3.93	-15.24	-18.00	867.26	221.61	14.61	1.11	-2.78	11.68
73	14.00	7.83	400.50	-2.14	-0.06	3.00	-0.16	-5.33	/	-16.67	197.77	47.99	25.73	37.95	/
74	2.74	18.76	473.87	7.22	2.15	4.05	-0.48	/	/	189.25	529.84	211.98	20.78	/	/
75	48.69	-14.23	263.33	-21.59	-4.48	1.48	/	/	/	27.31	189.59	137.22	/	/	/
76	-0.44	-5.62	576.80	-1.50	-4.28	-8.43	-4.84	-18.68	-22.40	-27.85	66.92	107.40	33.46	27.10	96.75
77	24.98	-9.87	449.84	-0.31	-0.13	2.45	-0.30	/	/	-22.53	78.59	150.18	20.10	0.00	/
78	24.94	-4.32	420.43	0.07	0.90	4.90	0.63	/	/	-11.66	136.97	233.41	23.37	0.00	/
79	-0.44	-5.62	576.80	-1.50	-4.28	-8.43	-4.84	-18.68	-22.40	-27.85	66.92	107.40	33.46	27.10	96.75
80	24.95	-7.18	433.48	-0.40	0.27	3.52	0.12	/	/	-18.31	158.59	177.62	20.96	/	/
81	-0.41	-0.69	552.18	-0.33	-3.29	-6.44	-4.13	-16.85	-20.72	-12.41	201.01	27.37	31.39	26.46	-13.26
82	-0.30	5.50	583.52	8.95	0.60	-0.64	-2.41	-12.90	-17.39	434.92	685.56	60.24	2.39	6.51	30.70
83	42.35	-34.23	582.75	4.18	-0.41	0.07	-1.35	/	/	149.04	650.18	214.38	21.73	/	/
84	23.32	-9.13	466.00	1.57	0.37	2.83	-0.28	-5.49	/	-16.41	155.95	47.64	30.55	42.30	/
85	-8.19	43.82	392.41	-1.14	-0.48	0.33	-1.74	-11.07	/	-12.71	99.28	134.92	31.83	40.83	/
86	18.68	-17.15	534.42	-0.42	-2.33	-3.35	-2.66	-12.03	/	-18.03	438.22	107.76	7.59	27.80	/
87	26.56	-3.10	405.14	-0.13	1.31	6.10	1.13	/	/	-12.40	8.03	196.97	13.48	/	/
88	2.81	30.61	384.94	1.00	1.50	4.95	/	/	/	-42.45	565.30	143.62	/	/	/
89	42.36	-28.16	488.19	-1.25	-1.14	0.69	-0.75	/	/	-20.86	42.34	193.44	21.84	/	/
90	14.00	7.83	400.50	-2.14	-0.06	3.00	-0.16	-5.33	/	-16.67	197.77	47.99	25.73	37.95	/
91	-3.55	58.60	329.06	0.54	2.78	7.66	/	/	/	-34.73	541.61	149.22	/	/	/
92	-0.44	-5.62	576.80	-1.50	-4.28	-8.43	-4.84	-18.68	-22.40	-27.85	66.92	107.40	33.46	27.10	96.75
93	36.01	-35.25	593.82	-0.41	-3.04	-4.83	-3.09	-12.76	/	-18.54	102.77	173.65	12.99	-2.78	/
94	-0.44	-5.62	576.80	-1.50	-4.28	-8.43	-4.84	-18.68	-22.40	-27.85	66.92	107.40	33.46	27.10	96.75
95	2.82	103.22	221.96	3.77	10.33	/	/	/	/	93.77	455.89	/	/	/	/
96	23.32	-9.13	466.00	1.57	0.37	2.83	-0.28	-5.49	/	-16.41	155.95	47.64	30.55	42.30	/
97	17.06	-14.45	520.46	-0.94	-2.36	-3.22	-2.59	-11.87	/	-28.39	107.59	157.37	15.17	26.29	/
98	-8.19	43.82	392.41	-1.14	-0.48	0.33	-1.74	-11.07	/	-12.71	99.28	134.92	31.83	40.83	/
99	43.94	31.11	215.60	-1.99	10.28	/	/	/	/	-8.82	443.53	/	/	/	/
100	48.69	-31.47	508.00	1.86	0.13	2.70	-0.08	/	/	162.93	105.18	209.13	18.06	/	/

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