 Collect. Vol. Sci. Pap. ICCAT, 74(6): 2635-2656 (2018)

VALIDATION OF THE GROWTH EQUATIONS APPLICABLE TO THE ATLANTIC BLUEFIN TUNA, *THUNNUS THYNNUS* (L.), USING L_{MAX}, TAG-RECAPTURE, LENGTH-WEIGHT RELATIONSHIPS, CONDITION FACTOR AND FIRST DORSAL SPINE ANALYSIS

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SUMMARY

The growth equations currently used for Atlantic bluefin tuna, Thunnus thynnus (L.), western stock (Lt = 314.90 [1- e- 0.089 (t + 1.13)]) and eastern stock (Lt = 318.85 [1- e- 0.093 (t + 0.97)]), are re-validated using several approaches. The first method involved a comparison of studies with von Bertalanffy parameter estimates taking as references *Lmax= 319.93 ± 11.3 cm. The result of this analysis shows that the growth equations used by ICCAT's SCRS ABFT assessment group lie within the confidence limits of Lmax. Validation of the ABFT growth equations are also made by using different length-weight relationships, K (condition factor), tag-recovery data from tagging surveys (Bay of Biscay, western Mediterranean and western Atlantic) and spine readings to the growth equations and analyzing residuals. The R2= 97.98 and the residual's distribution indicated good performance of the models. With the present study, it is demonstrated that the new growth model that the ABFT group intends to adopt in 2017 does not fit the biology of the growth of ABFT, and there is no justification for changing the equations currently available.*

RÉSUMÉ

Les équations de croissance actuellement utilisées pour le thon rouge de l'Atlantique, Thunnus thynnus (L.), *le stock occidental (Lt = 314,90 [1-e-0,089 (t + 1,13)]) et le stock oriental (Lt = 318,85 [1-e-0,093 (t + 0,97)]), sont revalidées à l'aide de plusieurs approches. La première méthode consistait en une comparaison des études avec les estimations des paramètres de von Bertalanffy en prenant comme référence Lmax = 319,93 ± 11,3 cm. Le résultat de cette analyse montre que les équations de croissance utilisées par le groupe d'évaluation ABFT du SCRS de l'ICCAT se situent dans les limites de confiance de Lmax. La validation des équations de croissance de l'ABFT sont également faites en utilisant différentes relations de longueur-poids, K (coefficient de condition), des données de marquage-récupération provenant de prospections de marquage (golfe de Gascogne, ouest de l'Atlantique et de la Méditerranée) et de lectures de la colonne vertébrale aux équations de croissance et en analysant les valeurs résiduelles. R2 = 97,98 et la distribution des valeurs résiduelles ont indiqué une bonne performance des modèles. Avec la présente étude, il est démontré que le nouveau modèle de croissance que le groupe ABFT a l'intention d'adopter en 2017 ne correspond pas à la biologie de la croissance de l'ABFT, et il n'y a aucune justification pour changer les équations actuellement disponibles.*

RESUMEN

Se revalidan las ecuaciones de crecimiento utilizadas actualmente para el atún rojo del Atlántico, Thunnus thynnus, (L.), stock occidental (Lt = 314.90 [1- e- 0.089 (t + 1.13)]) y stock oriental (Lt = 318.85 [1- e- 0.093 (t + 0.97)]), utilizando diversos enfoques. El primer método implicaba una comparación de estudios tomando las estimaciones del parámetro von Bertalanffy como referencia Lmax= 319.93 ± 11.3 cm. El resultado de este análisis muestra que las ecuaciones de crecimiento utilizadas por el grupo de evaluación de atún rojo del Atlántico (ABFT) del SCRS recaen dentro de los límites de confianza de Lmax. Se realizó también la validación de las ecuaciones de crecimiento del ABFT utilizando diferentes relaciones talla-peso, K (factor de condición), datos de marcado-recaptura de prospecciones

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de marcado (golfo de Vizcaya, Mediterráneo occidental y Atlántico occidental) y lecturas de espinas para las ecuaciones de crecimiento, y analizando los datos residuales. R2= 97,98 y la distribución de los datos residuales indicaba un buen funcionamiento del modelo. Con este estudio, se demuestra que el nuevo modelo de crecimiento que el grupo de ABFT tiene intención de adoptar en 2017 no se ajusta a la biología de crecimiento del ABFT y no existe justificación para cambiar las ecuaciones actualmente disponibles.

KEYWORDS

Age, growth equations, Atlantic bluefin tuna, Thunnus thynnus

1. Introduction

The International Commission for the Conservation of Atlantic Tunas (ICCAT) is responsible for managing the Atlantic Bluefin Tuna (ABFT), *Thunnus thynnus* (L.). As part of the management of this species, ICCAT manages the species as two stocks, a western stock and stock eastern (which includes the Mediterranean). The boundary between the two stocks is defined as the 45° W meridian. However, in reality, high rates of mixing, varying from one year to the other, has been demonstrated (ICCAT, 2010).

Stock assessments for the ABFT made by the Standing Committee on Research and Statistics (SCRS) of ICCAT follow the designation of two separate stocks and apply a different growth equation to each. In 2010 the SCRS ABFT assessment group replaced the previous growth equation for the western stock (Turner and Restrepo, 1994) with a new one put forward by Restrepo *et al.* (2010, Equation 1); the resulting curve was also found to be very similar to the curve adopted by the assessment group for the eastern stock since 1991 (Cort, 1991; Cort *et al*., 2014; Equation 2). Both equations are based on a combined growth curve using modal progression data and direct age-length observations, otoliths for western Atlantic ABFT and fin spines sections for eastern Atlantic ABFT (**Figure 1**).

$$L_t = 314.90\ [1- e^{-0.089\ (t + 1.13)}] \qquad \text{(Equation 1)}$$
$$L_t = 318.85\ [1- e^{-0.093\ (t + 0.97)}] \qquad \text{(Equation 2)}$$

Thirty seven studies have been carried out looking at eastern ABFT growth (e.g. Farrugio, 1979; Rooker *et al*., 2007; Rodríguez-Marín *et al*., 2007; Milatou and Megalofonou, 2014; and others mentioned in the present study) and eighteen in the western ABFT (e.g. Farrugio, 1979; Rooker *et al*., 2007; Neilson and Campana, 2008; Secor *et al*., 2009; Restrepo *et al*., 2010); an additional study (Ailloud *et al*., 2013) is common for both stocks. The assumptions and methodologies used by the various authors to carry out these growth studies were highly varied resulting in significantly different estimates of L_∞ in the resulting growth models.

Based on a sample of around 2.5 million ABFT, Cort *et al*. (2013) estimated the maximum fork length (L_{max}) as 319.93 ± 11.3 cm by calculating the mean L_{max} observed in eastern Atlantic and Mediterranean ABFT fisheries. In calculating the confidence intervals, the hypothesis of normality was assumed, and results were fully consistent with actual data observed in the samples. The study concluded that the mean asymptotical length parameters, L_∞= 314.9 cm (from Equation 1) and L_∞= 318.85 cm (from Equation 2), lie within these confidence limits.

In light of the existence of numerous growth models and the latest information, the specific objectives of the present study are:

- i) To review the ABFT growth studies in the Atlantic and Mediterranean with the aim of determining those which better estimate ABFT growth.
- ii) To review the assumptions made and the methodologies used in the determination of the ABFT growth equations for the eastern and western stocks by analysing information available in the literature.
- iii) Compare the values of W_∞ that are obtained using different length-weight relationships and the condition factor K applied to the models of Restrepo *et al*. (2010), Cort (1991, Cort *et al*., 2014), as well as to a new growth model (Ailloud *et al*., 2016) that the SCRS has recommended to implement to the two stocks in the future.

iv) To report on the correlation of tag-recapture data and first dorsal spine readings with the ABFT growth equations currently (pre-2017) used for the eastern and western stocks as a means of validating these equations.

The present study is an adaptation of the article published by Cort *et al*. (2014).

2. *M*aterial and Methods

2.1. Literature review and L_{max} *analysis*

Of the fifty five studies on absolute growth made for ABFT (Fork length > 50 cm) in the Atlantic and Mediterranean, the thirty two containing growth equations were analysed. In total, forty three equations were analysed on the basis of the L_{max} and the confidence intervals shown in Cort *et al*. (2013). The analysis omitted four equations in which L_∞ is > 4 m (Sella, 1929; Farrugio, 1978; Arena, 1980; Farber and Lee, 1981). The equations of Ailloud *et al*. (2013) and Rodríguez-Marín *et al*. (2016) are common to western and eastern stocks, and the equation of Milatou and Megalofonou (2014) is based on capture-based aquaculture where fish sampled had been reared in sea cages for 6-7 or 18 months after their arrival at the farm.

2.2. Validation of growth equations (Cort, 1991; Cort et al., 2014; Restrepo et al., 2010)

The growth equation for the eastern Atlantic bluefin tuna stock (Cort, 1991; Cort *et al*., 2014) is a combined growth curve using modal progression data for ages 1 to 8 (53.5-177.2 cm) from the Bay of Biscay (Cort, 1990) and direct age-length observations (fin spine sections) for ages 9-15 (190-247 cm) from the traps of southern Spain (Rey *et al*., 1987; Cort, 1990). Samples used correspond to the month of June, the month of birth for the ABFT in the western Mediterranean (García *et al*., 2003 and 2005); this makes the sampling season equivalent in both areas. By grouping the mean values at age from the Bay of Biscay with those of the traps, the von Bertalanffy (1938) growth model could be applied. Cort *et al*. (2014) used the same data and tag-recovery data from tagging surveys in the Bay of Biscay, western Mediterranean and western Atlantic (*n*= 131).

Restrepo *et al*. (2010) used combine otolith-based age readings with the size frequency distributions of small (ages 1–3) ABFT caught by purse seiners in the 1970s; the accuracy of the age readings has been validated with bomb radiocarbon dating (Neilson and Campana, 2008). These age readings are primarily for large ABFT (ages 5 and older), and indicate slower growth and older ages than was previously assumed (Turner and Restrepo, 1994). However, an analysis of these data resulted in growth curves that predicted very small mean sizes for the youngest age group, which could be a result of the lack of small fish in the data used.

2.2.1. Length-weight relationships applicable to different growth models and estimation of K

The values of W_∞ obtained by applying the different asymptotic values (L_∞) of the growth equations of Restrepo *et al*. (2010), Cort (1991; Cort *et al*., 2014), and Ailloud *et al*. (2016) with length-weight relationships used in the ABFT group, such as Parrack and Phares (1979), Arena (1980), ICCAT (2013), and Rodríguez-Marín *et al*. (2015) are compared. Fulton's condition factor *K* (Ricker, 1975) is also applied to the different values of L_∞.

2.2.2. Analysis of conventional tag-return and fin spine readings

The validation of the eastern and western Atlantic growth equations now in use was made by superimposing tag-recovery data from the Atlantic and Mediterranean conventional tagging surveys and spine reading data on the growth curve (**Appendices 1 & 2**, taken from Cort, 2009). Tag-recapture observations from the Spanish IEO tagging surveys in the Bay of Biscay and western Mediterranean between 1978 and 1991 (Cort and De la Serna, 1994; Cort and Liorzou, 1995) are added. This database contains 6,047 records of fishes tagged, of which 400 were recovered. Recoveries of ABFT aged over twelve years from western Atlantic tagging surveys on the ICCAT conventional tag-recapture database are also included in the analysis and compared. The database, obtained during a period of thirty six years (1965-2001), contains 60,167 records corresponding to tagged ABFT, of which 2,957 were recovered (up to 2011).

The age of fish tagged was assigned using age length keys (ALKs) from Rey and Cort (1984) and Cort (1990). Only data of ABFT measured at the time of tagging, to which age could be assigned with hardly any margin of error, were used. Thereafter, ABFT between 1 and 3 years at time of release were considered. One single exception was that of a four year old fish which was recovered (PE313); this was of great interest since its *L* at the time of capture (120 cm) required its allocation to age 4.

Final age estimated is the initial age plus the time at liberty. Taking account that the eastern ABFT growth curve refers to June as the month of birth in the eastern stock and May for the western Atlantic stock (Baglin, 1982), month fractions were assigned to ages. This means that if a fish of 80 cm (two years old) was recovered in the eastern Atlantic in August, the age assigned was 2.2 years. When necessary, length or *RWT* measurements were converted to *L*. In the latter two (June-September or October-December) the *L-W* relationships of Cort (1990) were applied.

L residuals distribution as a function of age was analysed. In order to measure the precision and accuracy of the curve as predictor, the mean of the absolute value of the prediction errors (absolute value of the difference between the estimated *L* and the measured *L*) and the mean of the relative percentage of prediction errors (absolute value of the prediction error/predicted *L* x 100) were calculated.

3. Results

3.1. Literature review and $L_{\max}$ analysis

The methodologies used to carry out all the growth studies were highly varied: scales (Westman and Gilbert, 1941; Bell, 1963); caudal or precaudal vertebrae (Sella, 1929; Hamre, 1958; Vilela and Pinto, 1958; Vilela, 1960; Rodríguez-Roda, 1964 and 1974; Farrugio, 1980; Ólafsdóttir and Ingimundardóttir, 2000 and 2003; Milatou and Megalofonou, 2014); caudal vertebrae and back calculated *L* (Farber and Lee, 1981); modal progression (Buser-Lahaye and Doumenge, 1954; Doumenge and Lahaye, 1958; Farrugio, 1978, using Sella´s 1929 data; Farrugio, 1980; Arena *et al*., 1980; Liorzou and Bigot, 1995); modal progression and vertebrae (Mather and Schuck, 1960; Berry and Lee, 1977); otoliths (Caddy *et al*., 1976; Butler *et al*., 1977; Hurley and Iles, 1983; Neilson and Campana, 2008; Secor *et al*., 2009; Golet, 2010); modal progression and otoliths (Restrepo *et al*., 2010); otoliths and back-calculated *L* (Hattour, 1984), otoliths and tag-recapture (Ailloud *et al*., 2016); fin spines sections (Compeán-Jiménez and Bard, 1983; Megalofonou and De Metrio, 2000; Chalabi *et al*., 2001; Farrugia and Rodríguez-Cabello, 2001; El-Kebir *et al*., 2002; Rodríguez-Marín *et al*., 2004; Santamaria *et al*., 2009; Luque *et al*., 2011; Luque *et al*., 2014); tag-recapture (Parrack and Phares, 1979; Farber and Lee, 1981; Turner and Restrepo, 1984; Rodríguez-Cabello *et al*., 2007; Ailloud *et al*., 2013); back-calculated *L* (Landa *et al*., 2011; 2012 and 2015); fin spines sections and otoliths from the same fish (Rodríguez-Marín *et al*., 2013a; Rodríguez-Marín *et al*., 2016); age-length key (Neghli and Nouar, 2013); combined modal progression, ages 1 to 3, and data from Rodríguez-Roda (1964) for ages 4 to 13 (Bard *et al*., 1978); combined modal progression data, ages 1 to 8, and fin spines sections, ages 9 to 15 (Cort, 1991); combined modal progression data, ages 1 to 8, and fin spines sections, ages 9 to 15 and tag-recapture (Cort *et al*., 2014), and diverse methods not specified (Le Gall, 1954; Scaccini, 1965; Mather and Jones, cited by Sakagawa and Coan, 1973; Coan, 1975, and Hunt, 1977).

The twenty four studies on the growth of eastern ABFT providing growth equations are summarised in **Table 1**. In two of them (Santamaria *et al*., 2009; Neghli and Nouar, 2013), data are presented separated by sexes, all others do not differentiate between sexes.

The fourteen studies on the growth of western ABFT providing growth equations are summarised in **Table 2**.

Figure 2 shows the 43 values of L_∞ predicted by each of the models presented in **Tables 1** and **2** in relation to the $L_{\max}$ estimate for ABFT (Cort *et al*., 2013). The three values in which $L_\infty > 4$ m are excluded from the figure.

The statistics of the analysis are shown in **Table 3.** Values where $L_\infty > 4$ m are included under AUL (above the limit of $L_{\max}$).

The L_∞ values of all of the equations given in the papers listed in **Table 1** and **Table 2** lie between 257 cm (Secor *et al*., 2009) and 499.68 cm (Farrugio, 1978, using Sella´s, 1929 data). The statistics of the analysis show that 76 % of the total equations presented in **Tables 1** and **2** give L_∞ values are outside the 95 % confidence limits of $L_{\max}$.

Santamaria *et al*. (2009) in the Mediterranean, and Caddy *et al*. (1976), Butler *et al*. (1977) and Hurley and Iles (1983) in the western Atlantic, found different growth rates for males and females, with growth rates of the males being faster than that of females.

In studies in which the sexes are not discriminated, the growth rate (k) is similar in all of the equations, except for Farrugio (1978) and Chalabi (2001). t_0 is positive in Ólafsdóttir and Ingimundardóttir (2000 and 2003), Hurley and Iles (1983) and Secor *et al*. (2009), and 0 in Neghli and Nouar (2013) which, according to their explanation, is a consequence of the method and the analytical software used by these authors (described by Tomlinson and Abramson, 1961; Gayanilo *et al*., 2005). In Rodríguez-Cabello *et al*. (2007) no value for t_0 was obtained due to the methodology used, as described in their paper. In practice this is identical to assuming $t_0 = 0$.

Figure 3 shows the estimated growth curves of the eleven studies from ABFT (eastern and western stocks) in which the values of L_∞ lie within the limits of $L_{\max}$. The differences between the growth curves are down to the values of t_0, which is equal to 0 in the case of Neghli and Nouar (2013). Neghli and Nouar (2013) provided 3 sets of growth parameters - for males, females and sexes combined. Only those for males and the combined data fell within the limits of $L_{\max}$.

3.2. Length-weight relationships applicable to different growth models

The values of W_∞ obtained by applying L_∞= 263.77 (Ailloud *et al*., 2016) are very different to what we know about the biology of ABFT (**Table 4**); In none of the cases studied using this equation are fish of 400 kg in weight reached, a result which does not coincide with reality. Lebedeff (1936) and Heldt (1938) provide ABFT biometric measurements of 725 kg and 330 cm from the Sea of Marmara (Turkey). Crane (1936) reported a 726 kg ABFT observed at Portland, Maine (USA), although unofficial, and later Fraser (2008) captured in Aulds Cove (Nova Scotia, Canada) an ABFT of 304-320 cm (679 kg), according to Cort *et al*. (2013). In addition, in the past and even in recent years, fish of over 500 kg are caught, even up to weights of 700 kg (ICCAT Database).

L_∞ (314.9 cm) provided by Restrepo *et al*. (2010) and the L_∞ (318.85 cm) of Cort (1991; Cort *et al*., 2014) both produce much more realistic values of W_∞. In addition, the condition factor, *K*, calculated for the different values of *W* gives unrealistic values when using L_∞= 263.8 from Ailloud *et al*. (2016), **Table 5**.

3.3. Conventional tag-return and fin spines readings analysis

Figure 4A shows the fit of the growth curve with the 121 recoveries from the eastern Atlantic and 10 recoveries over twelve years old from the western Atlantic. The maximum age reached in the recoveries from the eastern Atlantic and Mediterranean was twelve years (two fishes were eleven years at liberty). The maximum age reached in the recoveries from the western Atlantic is twenty years (one fish was eighteen years at liberty). The most reliable data of ABFT tagged in the western Atlantic come from the purse seine tagging surveys in the 1960´s and 1970´s. The 299 spine readings from the eastern Atlantic fisheries, whose list is presented in Cort (2009), are also included in **Figure 4A**.

Figure 4B represents the residuals versus age and **Table 6** represents the residuals and precision measures of the predictive accuracy of the curve from Restrepo *et al*. (2010) and values for the curve of Cort (1991) and Cort *et al*. (2014). All data used for this analysis come from the publication Cort (2009).

4. Discussion

Literature review and $L_{\max}$ analysis

The growth equations available in the literature for this species were analysed to determine which provides the best representation of the known biology of the ABFT. In total, fifty five studies looking at the absolute growth of the ABFT were available of which thirty one presented a total of forty three growth equations. Only eleven of these equations (Bard *et al*., 1978; Parrack and Phares, 1979; Farber and Lee, 1981, tag recapture; Hattour, 1984; Cort, 1991; Restrepo *et al*., 2010; Neghli and Nouar, 2013 (males and combined); Luque *et al*., 2014; Rodríguez-Marín *et al*., 2016) have the value of L_∞ within the limits of $L_{\max}$= 331.23-308.63 (95 %) cm. It should be pointed out that of these studies, those of Bard *et al*. (1978), Cort (1991) and Restrepo *et al*. (2010) were made using the same methodology, that is, a combination of modal progression of the juvenile fisheries of the eastern Atlantic and mean values/age for adult fishes.

This updated review presented here demonstrates the availability of a large body of literature on age estimation and absolute growth of ABFT. With the analysis carried out here, it is clearly possible to identify and conclude which are the equations that best fit the known growth biology of this species, thereby ensuring the most accurate stock assessments of this species can be carried out.

Indirect validation of the growth equations (Cort, 1991; Cort et al., 2014; Restrepo et al., 2010)

Simple observation of the actual data superimposed on the growth curve and the global R^2 value (0.9798) indicates good performance of the model (**Figure 4A**). However, the only way to assess the predictive power of the curve is a subsequent observation and analysis of the residuals. In the figure where residuals versus age are depicted (**Figure 4B**), the general random distribution on both sides of the abscissa indicates that there are no systematic errors in the model specification. The random distribution propertie of the residuals seems not to be locally satisfied because in the first ages (0 to 2) smaller range of the residuals is observed. But this is reasonable because smaller sizes imply higher precision in the relationship under consideration and thus small absolute values of the residuals. Moreover, the mean of the absolute errors and the mean of the relative errors (around 5%) of the recoveries and fin spines readings indicate the stability of the models from the point of view of its predictive power.

The consistency of the tag-recovery data with the growth curves used for the western and eastern ABFT stocks support the growth models currently used by the SCRS. Clearly, no statistically significant differences between the models (Restrepo *et al*., 2010; Cort, 1991; Cort *et al*., 2014) can be established. Similarly, superimposing the first dorsal fin spine readings on the growth curves also confirms the goodness of the fit of the growth curves, and the reasonable homoscedasticity of the residuals reveal the goodness of the Restrepo *et al*. (2010) and Cort (1991; Cort *et al*., 2014) growth equations.

With respect to the spine readings of ABFT from traps in 1984, the revision of the oldest available sample by bomb radiocarbon assay made by Rodríguez-Marín *et al*. (2013b) (*L*, 304 cm, presumed age of 22 years), could improve slightly the fit of the eastern model. This ABFT had been previously been estimated to be 19 years old by Rey *et al*. (1987) and Cort (1990 and 1991).

The analysis presented here demonstrates that the growth models which have been used up to 2016 for the stock assessment of the western and eastern stocks ABFT by the SCRS are indeed models which most accurately represent the growth biology of the ABFT.

In view of the above, it is considered that the decision of the SCRS ABFT evaluation group to replace the growth equations currently in force (Restrepo *et al*., 2010, Cort, 1991 Cort *et al*., 2014) by a new one (Ailloud *et al*., 2016), as stated in the 2016 data meeting report (ICCAT, 2016), is not the most appropriate taking into account that the proposed new model does not fit the value of L_{max} of ABFT, nor the size-weight models and *K*.

It is recommended that this decision be reconsidered in light of the above and the evidence that indicates that the models used so far do conform to L_{max}, length-weight relationships, *K* and the tag-recapture and spine reading data as demonstrated in the present study.

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Table 1. Growth parameters for eastern ABFT from different studies.

	L_{∞} (cm)	*k*	t_0	Method
Rodríguez-Roda (1964)	344.1	0.090	-0.97	Vertebrae
Rodríguez-Roda (1974)	335.84	0.090	-0.89	Vertebrae
Bard et al. (1978)	317.8	0.1091	-0.62	Modal progression, ages 1 to 3 + Rogríguez-Roda (1964), ages 4 to 13
Farrugio (1978)	499.68	0.440	-2.113	Using Sella´s (1929) data (vertebrae)
Farrugio (1980)	351.2	0.080	-1.087	Vertebrae
Farrugio (1980)	331.42	0.066	-2.276	Modal progression
Arena et al. (1980)	455.89	0.05	-1.613	Modal progression
Compeán-Jimenez and Bard (1983)	372.2	0.068	-1.710	Fin spine sections
Hattour (1984)	330	0.095	-0.366	Otoliths. Back calculated *FL*
Cort (1991)	318.85	0.093	-0.970	Modal progression and fin spine sections
Ólafsdóttir and Ingimundardóttir (2000)	307.1	0.0897	2.903	Vertebrae
Chalabi et al. (2001), cited by Neghli and Nouar (2013)	298.5	0.240	-0.860	Fin spine sections
Ólafsdóttir and Ingimundardóttir (2003)	258.4	0.154	1.185	Vertebrae
Rodríguez-Cabello et al. (2007)	281.9	0.10	-	Tag recapture
Santamaria et al. (2009)	382	0.06	-1.75	Fin spine sections, males
Santamaria et al. (2009)	349	0.07	-1.63	Fin spine sections, femeles
Santamaria et al. (2009)	373.1	0.07	-1.76	Fin spine sections, combined
Landa et al. (2011)	341	0.090	-0.85	Back calculated *FL*
Landa et al. (2011)	348	0.090	-0.87	Back calculated *FL*
Luque et al. (2011)	382.6	0.070	-1.33	Fin spine sections
Neghli and Nouar (2013)	321.27	0.11	0	Age length key, males
Neghli and Nouar (2013)	306.57	0.12	0	Age length key, femeles
Ailloud et al. (2013)	358.5	0.08	-1.04	Tag recapture
Neghli and Nouar (2013)	314.92	0.11	0	Age length key, combined
Rodríguez-Marín et al. (2013a)	380.2	0.074	-1.18	Fin spine sections
Rodríguez-Marín et al. (2013a)	392.5	0.065	-1.65	Otoliths
Luque et al. (2014)	327.4	0.097	-0.838	Fin spine sections
Milatou and Megalofonou (2014)	360.3	0.083	-0.942	Vertebrae
Landa et al. (2015)	349.5	0.086	-0.814	Back calculated *FL*
Rodríguez-Marín et al. (2016)	324.4	0.093	-0.853	Otoliths
Rodríguez-Marín et al. (2016)	318.5	0.101	-0.802	Fin spine sections

Table 2. Growth parameters for western ABFT from different studies.

	L_∞ (cm)	*k*	t_0	Method
Mather and Schuck (1960)	371	0,069	-1.373	Modal progression and caudal vertebrae
Caddy et al. (1976) and Butler et al. (1977)	286,6	0,134	-0.328	Otoliths, males
Caddy et al. (1976) and Butler et al. (1977)	277,3	0,116	-0.800	Otoliths, females
Hunt (1977)	289,9	0,1137	-0.665	Diverse
Parrack and Phares (1979)	313	0,09	-0.960	Tag recapture
Farber and Lee (1981)	313	0,12	-0.140	Tag recapture
Farber and Lee (1981)	401	0,08	-0.920	Caudal vertebrae and back calculated *L*
Hurley and Iles (1983)	277,8	0,169	0.254	Otoliths, males
Hurley and Iles (1983)	266,4	0,17	0.106	Otoliths, females
Turner and Restrepo (1994)	382	0,079	-0.707	Tag recapture
Neilson and Campana (2008)	289	0,116	-0.06	Otoliths
Secor et al. (2009)	257	0,2	0.83	Otoliths
Restrepo et al. (2010)	314,9	0,089	-1.13	Modal progression and otoliths
Golet (2010)	346	0,092	-0.598	Fin spine sections
Ailloud et al. (2013)	358,5	0,08	-1.04	Tag recapture
Ailloud et al. (2016)	263,8			Otoliths & Tag recapture

Table 3. Statistics of the analysis of the L_∞ values of the different ABFT growth equations in relation to L_{max}. Below the lower limit of L_{max}, BLL; above the upper limit of L_{max}, AUL and within the limits of L_{max}, AL.

	Frequency	Relative Frequency	Cumulative Frequency	Cumulative Relative
BLL	13	28.00%	13	28.00%
AUL	22	48.00%	35	76.00%
AL	11	24.00%	46	100%

Table 4. Calculated values of W_∞ determined from different *L-W* equations.
(1), Ailloud *et al*. (2016); (2), Cort (1991), Cort *et al*. (2014); (3), Restrepo *et al*. (2010)

	Arena (1980); ICCAT (2013) Easter stock	R. Marín et al. (2015) Easter stock	R. Marín et al. (2015) Western stock	Parrack & Phares (1979) Western stock
a	0.0000196	0.0000351	0.0000177	0.0000152
b	3.009	2.8785	3.0013	3.0531
L_∞ (cm)	W_∞ (kg)	W_∞ (kg)	W_∞ (kg)	W_∞ (kg)
263.77 (1)	378.2	327.2	327.2	375.0
314.9 (2)	644.6	544.9	556.9	644.2
318.85 (3)	669.2	564.8	578.1	669.2

Table 5. Values of *K* obtained by using diverse *W* applied to L_∞ of different authors.
(1), Ailloud *et al*. (2016); (2), Cort (1991), Cort *et al*. (2014); (3), Restrepo *et al*. (2010)

L_∞ (cm)	*W* 600 kg	*W* 650 kg	W_{max} 725 kg
263.77 (1)	3.3	3.5	4.0
314.9 (2)	1.9	2.1	2.3
318.85 (3)	1.9	2.0	2.2

Table 6. Analysis of the residual values for the models of Cort (1991; Cort *et al*., 2014) and Restrepo *et al*. (2010), in brackets.

	Count	Mean of the residuals (cm)	Standard error of the residuals (cm)	Mean of the absolute errors (cm)	Mean of the relative errors (%)
Recoveries from the eastern Atlantic	121	1.89 (2.90)	0.65 (0.67)	5.18 (5.50)	5.99 (6.16)
Recoveries from the western Atlantic	10	1.10 (7.76)	5.41 (5.41)	13.88 (15.20)	5.49 (6.08)
Fin spines readings	299	1.87 (6.77)	0.57 (0.58)	7.85 (9.12)	4.25 (5.04)
Total, R^2= 0.9798 (0.9714)	430	1.86 (5.70)	0.44 (0.47)	7.24 (8.24)	4.77 (5.38)

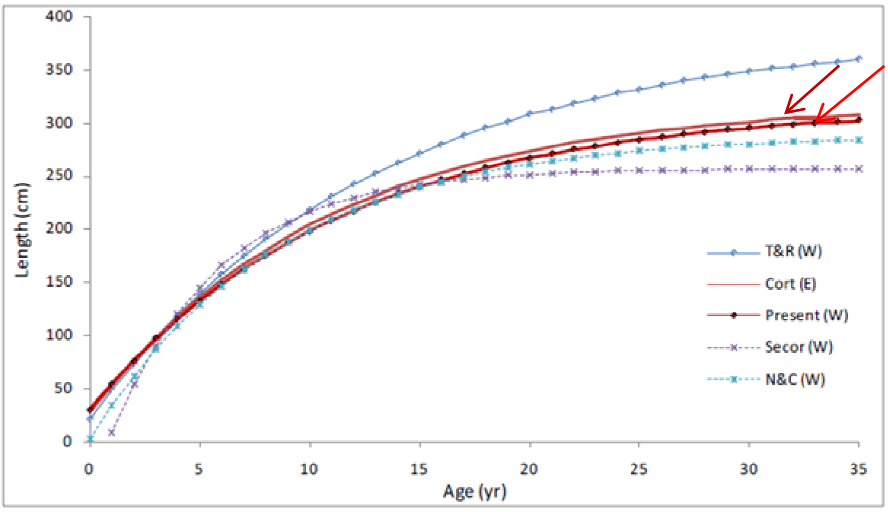

Figure 1. Estimated growth curves for Atlantic bluefin from Turner and Restrepo (1994), Secor *et al*. (2009), Neilson and Campana (2008), Restrepo *et al*. (2010) and Cort (1991), taken from Restrepo *et al*. (2010). The arrows show the similarity of the last two.

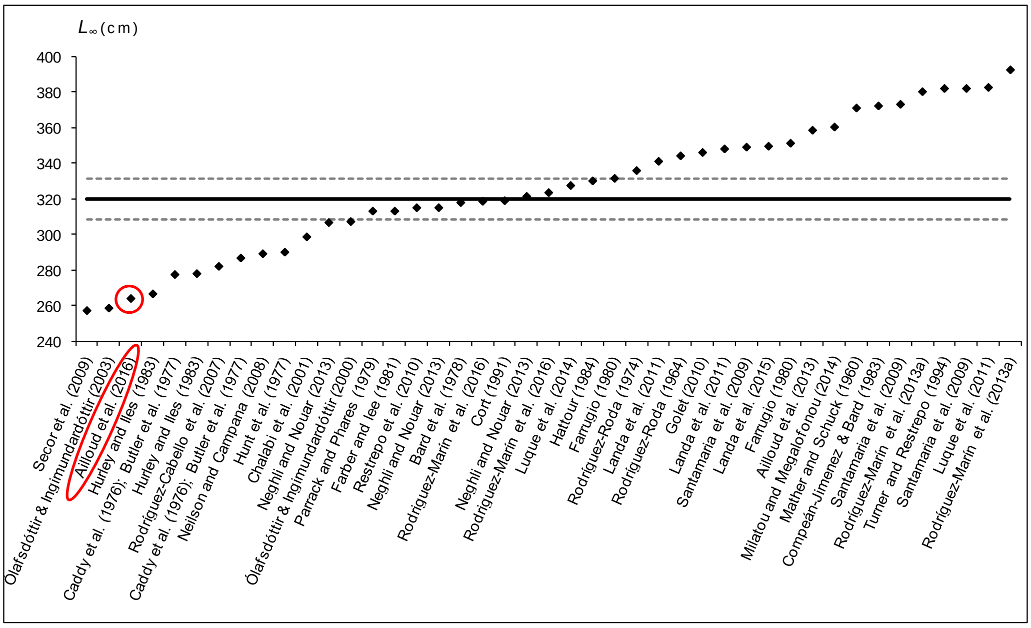

Figure 2. Analysis of the L_∞ values of the different ABFT growth equations in relation to L_{max} (with 95% confidence limits). The L_∞ of the model that SCRS intends to adopt for western and eastern stocks is marked.

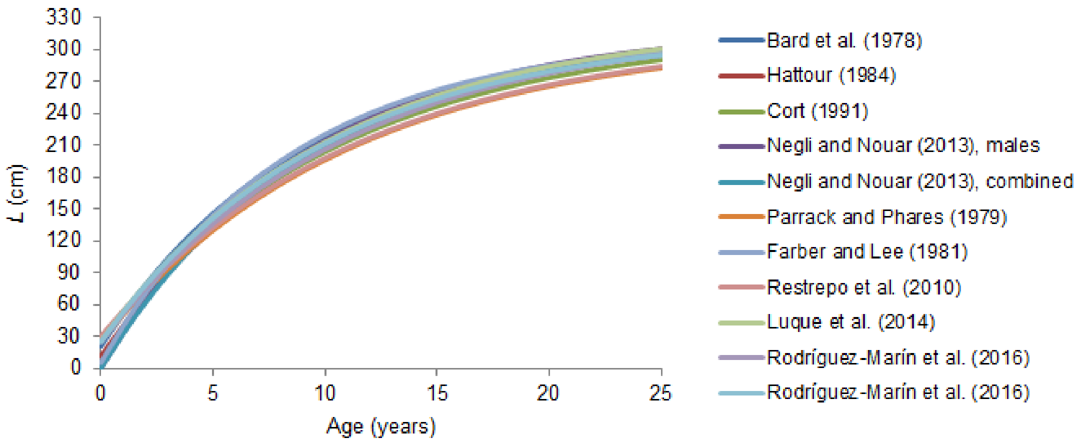

Figure 3. The eleven studies on ABFT growth in which values of L_∞ lie within the limits of L_{max}.

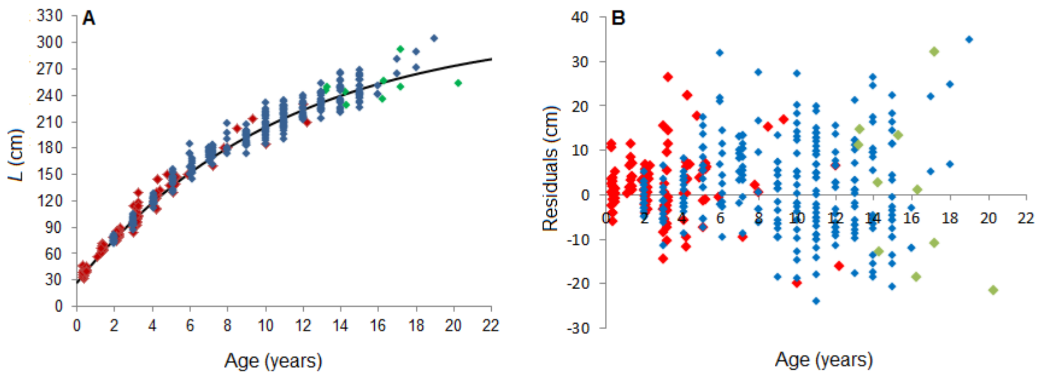

Figure 4A. Growth curve (Cort, 1991; Cort *et al*., 2014; solid line) superimposed on actual data points of 121 conventionally tagged ABFT recoveries from the eastern Atlantic and 10 recoveries over twelve years old from the western Atlantic. Figure 4B presents the residuals (cm) versus age (years) for spine readings of 299 eastern stock ABFT. Points in blue correspond to fin spines readings, in red to recoveries from the eastern Atlantic and in green to recoveries from the western Atlantic releases.

Appendix 1. Spanish recoveries superimposed on the curve (**Figure 4A**). Taken from Cort (2009).

TAG	DATE_T	CUAD_T	LAT_T	LONG_T	FL_T (cm)	CUAD_R	LAT_R	LONG_R	FL_R (cm)	W_R (kg)	DATE_R	AT LIBERTY (years)	AGE_R	OBSERVATIONS
AT 3070	01/08/1985	4	44,10	2,08	80	4	44,35	2,28	**86**	11	23/09/1985	-	**2.25**	< 2 months at liberty
AT 3138	02/08/1985	4	44,10	2,10	60	4	43,26	1,43	**79**	10	13/07/1986	1	**2.10**	-
AT 3311	06/07/1985	4	43,45	3,45	103	4	43,55	2,48	**118**	30	16/09/1985	-	**3.25**	< 3 months at liberty
AT 3584	10/08/1985	4	43,25	1,50	80	4	43,26	1,41	**98**	18	27/07/1986	1	**3.10**	-
AT 3611	10/08/1985	4	43,25	1,50	81	4	43,50	3,16	**136**	45	07/07/1988	3	**5.10**	-
AT 3680	30/09/1986	4	43,47	2,59	65	4	40,20	71,55	**147**	68	16/10/1990	4	**5.30**	-
AT 3869	30/09/1986	4	43,43	2,55	64	4	38,50	73,58	**114**	32	25/06/1988	2	**3.00**	-
AT 3878	30/09/1986	4	43,43	2,55	62	4	43,26	1,41	**95**	16	10/07/1988	2	**3.10**	-
AT 3884	30/09/1986	4	43,43	2,55	63	4	44,04	3,13	**90**	15	26/10/1987	1	**2.30**	-
AT 3930	30/09/1986	4	43,43	2,55	63	4	44,03	2,55	**64**	6	15/11/1986	-	**1.40**	< 2 months at liberty
AT 3991	30/09/1986	4	43,43	2,55	63	4	43,50	2,50	**67**	6	12/11/1986	-	**1.40**	< 2 months at liberty
EM 7221	05/10/1986	4	43,57	2,27	67	4	43,56	2,46	**92**	15	08/08/1988	2	**3.20**	-
EM 7320	06/10/1986	4	43,49	2,27	65	4	43,50	2,50	**67**	6	12/11/1986	-	**1.40**	< 2 months at liberty
EM 7340	06/10/1986	4	43,49	2,27	66	4	43,27	2,47	**69**	7	25/10/1986	-	**1.30**	< 2 months at liberty
EM 7351	06/10/1986	4	43,49	2,27	62	4	44,39	2,26	**87**	-	18/09/1987	1	**2.25**	-
EM 7361	06/10/1986	4	43,49	2,27	64	4	43,54	2,57	**64**	6	13/11/1986	-	**1.40**	< 2 months at liberty
EM 7431	06/10/1986	4	43,57	2,28	67	4	43,50	2,50	**67**	6	12/11/1986	-	**1.40**	< 2 months at liberty
EM 7458	07/10/1986	4	43,57	2,32	67	4	43,57	2,45	**72**	8	14/10/1986	-	**1.30**	< 1 month at liberty
EM 7465	07/10/1986	4	43,58	2,32	61	4	44,02	3,54	**77**	9	15/07/1987	1	**2.10**	-
EM 7476	07/10/1986	4	43,58	2,32	65	4	43,50	2,50	**65**	6	12/11/1986	-	**1.40**	< 2 months at liberty
EM 7486	07/10/1986	4	43,55	2,31	64	4	39,20	73,45	**100**	18	13/08/1988	2	**3.20**	-
EM 8001	27/07/1988	4	43,55	2,44	59	4	44,30	2,35	**64**	8	20/10/1988	-	**1.30**	< 3 months at liberty
EM 8015	27/07/1988	4	44,15	2,49	58	4	43,40	2,20	**61**	5	15/09/1988	-	**1.25**	< 2 months at liberty

EM 8137	31/07/ 1988	4	44,22	2,20	58	4	43,48	2,45	**83**	11	16/07/1989	1	**2.10**	-
EM 8168	31/07/ 1988	4	44,22	2,20	58	4	44,30	2,40	**70**	7	10/11/1988	-	**1.40**	< 4 months at liberty
EM 8182	31/07/ 1988	4	44,22	2,20	58	4	43,31	1,44	**78**	9	08/08/1989	1	**2.20**	-
EM 8242	31/07/ 1988	4	44,26	2,20	60	4	44,30	2,40	**70**	7	10/11/1988	-	**1.40**	< 4 months at liberty
EM 8286	31/07/ 1988	4	44,26	2,20	60	4	44,30	2,40	**70**	7	10/11/1988	-	**1.40**	< 4 months at liberty
EM 8321	02/08/ 1988	4	44,18	2,24	60	4	44,10	3,05	**77**	9	12/07/1989	1	**2.10**	-
EM 8322	02/08/ 1988	4	44,18	2,24	60	4	43,50	2,45	**84**	12	21/07/1989	1	**2.10**	-
EM 8431	02/08/ 1988	4	44,18	2,24	60	4	0,00	0,00	**85**	12	23/07/1989	1	**2.10**	-
EM 8566	04/08/ 1988	4	44,17	2,22	58	4	43,40	2,20	61	**5**	15/09/1988	-	**1.25**	< 2 months at liberty
EM 8639	04/08/ 1988	4	44,20	2,23	60	4	43,59	3,25	85	**12**	13/08/1989	1	**2.20**	-
KA 6043	27/08/ 1983	4	44,00	2,33	87	1	37,35	0,40	146	**53**	12/09/1986	3	**5.25**	-
KA 6096	27/08/ 1983	4	44,30	2,30	83	4	43,40	2,45	110	**25**	17/08/1985	2	**4.20**	Double tagging
KA 6097	27/08/ 1983	4	44,30	2,30	83	4	43,40	2,45	110	**25**	17/08/1985	2		Double tagging
KA 6800	21/08/ 1984	4	43,40	2,06	104	4	43,47	3,00	122	**-**	23/08/1985	1	**4.20**	-
KA 6916	22/08/ 1984	4	43,45	2,40	88	4	43,34	2,14	95	**16**	22/08/1985	1	**3.20**	-
KA 6924	22/08/ 1984	4	43,45	2,40	84	4	43,26	1,40	114	**27**	29/07/1986	2	**4.10**	-
KA 9694	26/08/ 1984	4	43,50	2,40	85	4	44,15	2,08	103	**20**	01/09/1985	1	**3.25**	-
KA 9713	26/08/ 1984	4	43,50	2,40	85	4	0,00	0,00	99	**18**	20/08/1985	1	**3.20**	-
KA 9730	27/08/ 1984	4	43,35	2,20	84	4	0,00	0,00	101	**-**	23/08/1985	1	**3.20**	-
KA 9754	29/08/ 1984	4	43,50	2,10	87	4	43,34	1,52	102	**20**	02/09/1985	1	**3.25**	-
KA 9760	29/08/ 1984	4	43,50	2,10	82	4	42,00	12,00	84	**13**	13/06/1985	1	**3.00**	-
KA 9779	29/08/ 1984	4	43,50	2,10	87	4	43,40	1,55	95	**16**	15/06/1985	1	**3.00**	-
KA 9834	29/08/ 1984	4	43,20	2,10	115	4	44,54	3,13	160	**-**	14/08/1988	4	**7.20**	-
NO 5817	17/08/ 1991	4	45,02	3,53	86	1	43,07	4,01	150	**57**	19/04/1994	3	**4.80**	-

NO 7368	28/08/ 1991	4	44,06	3,20	65	4	44,43	2,47	66	**6**	14/09/1991	-	**1.25**	< 1 month at liberty
NO 7646	22/10/ 1991	4	36,06	4,22	74	4	44,02	2,41	132	**48**	14/11/1994	3	**4.40**	-
PE 259	23/11/ 1983	4	37,08	1,48	32	4	37,08	1,48	32	-	27/11/1983	-	**0.40**	< 1 month at liberty
PE 273	23/11/ 1983	4	37,08	1,48	37	4	37,08	1,48	37	-	28/11/1983	-	**0.40**	< 1 month at liberty
PE 285	23/11/ 1983	4	37,08	1,48	40	4	36,59	1,52	40	-	28/11/1983	-	**0.40**	< 1 month at liberty
PE 313	16/08/ 1982	4	44,20	2,30	120	4	35,10	12,11	180	**113**	22/04/1986	4	**7.80**	-
PE 472	21/08/ 1984	4	43,40	2,06	112	4	43,48	2,55	125	-	22/08/1985	1	**4.20**	-
R 1697	19/08/ 1978	4	43,47	2,40	63	4	44,10	3,40	83	**12**	12/07/1979	1	**2.10**	-
R 6610	13/07/ 1977	4	33,40	8,10	56	4	28,00	12,00	78	-	28/05/1978	1	**1.90**	-
R 7388	13/09/ 1979	4	44,20	2,40	85	4	41,02	51,01	202	**150**	15/12/1985	6	**8.50**	-
R 8618	14/09/ 1979	4	44,30	2,40	62	4	43,58	2,48	83	**11**	04/08/1980	1	**2.20**	-
R 8629	14/09/ 1979	4	44,35	2,40	70	4	43,54	3,03	80	**10**	19/08/1980	1	**2.20**	-
R 8645	15/08/ 1980	4	43,44	2,56	80	4	43,32	2,26	101	-	20/07/1981	1	**3.10**	-
R 8657	15/08/ 1980	4	43,38	2,47	115	4	34,30	9,30	150	-	03/05/1983	3	**5.90**	-
R 8823	28/11/ 1983	4	37,08	1,48	38	4	37,07	1,49	41	-	12/12/1983	-	**0.50**	< 1 month at liberty
R 8841	30/11/ 1983	4	37,07	1,49	41	4	37,07	1,49	41	-	01/12/1983	-	**0.50**	< 1 month at liberty
R 9706	17/08/ 1980	4	43,40	3,15	60	4	40,36	72,03	112	-	13/08/1982	2	**3.20**	-
S 2258	10/08/ 1980	4	43,40	2,45	60	4	43,23	2,06	95	**17**	16/06/1982	2	**3.00**	-
S 2469	04/08/ 1980	4	43,55	3,03	80	4	39,40	72,40	99	-	10/08/1981	1	**3.20**	-
S 2479	04/08/ 1980	4	43,55	2,45	60	4	43,24	1,40	90	**17**	21/06/1982	2	**3.00**	-
S 2488	04/08/ 1980	4	43,55	2,40	60	4	43,55	2,45	75	**8**	27/07/1981	1	**2.10**	-
S 2496	04/08/ 1980	4	43,55	2,40	60	4	0,00	0,00	82	**12**	15/08/1981	1	**2.20**	-
S 5587	23/08/ 1981	4	43,26	2,26	78	4	43,46	2,45	96	-	15/08/1982	1	**3.20**	-
S 5598	23/08/ 1981	4	43,26	2,25	82	1	42,20	4,00	127	-	06/10/1983	2	**4.30**	-

S 5775	13/08/ 1982	4	44,30	2,25	60	4	36,50	7,40	139	**50**	12/09/ 1986	4	**5.25**	-
S 5805	13/08/ 1982	4	44,20	2,10	63	4	44,30	2,50	108	**23**	15/08/ 1984	2	**3.20**	-
S 5815	13/08/ 1982	4	44,20	2,10	62	4	43,50	2,54	128	**-**	22/08/ 1985	3	**4.20**	-
S 5837	13/08/ 1982	4	44,30	2,25	62	4	43,48	2,55	125	**-**	22/08/ 1985	3	**4.20**	-
S 5881	13/08/ 1982	4	44,30	2,25	60	4	37,22	3,27	184	**118**	03/06/ 1991	9	**10.00**	-
S 5896	13/08/ 1982	4	44,30	2,25	62	4	43,38	2,31	115	**28**	03/09/ 1984	2	**3.25**	-
S 5942	14/08/ 1982	4	44,20	2,10	78	4	36,20	5,30	143	**57**	24/07/ 1985	3	**5.10**	-
S 5964	14/08/ 1982	4	44,20	2,10	83	4	44,00	2,50	112	**-**	27/08/ 1984	2	**4.20**	-
TG 521	08/10/ 1986	4	43,56	2,27	66	4	43,45	2,40	145	**49**	24/08/ 1990	4	**5.20**	-
TG 575	08/10/ 1986	4	43,50	2,16	66	4	43,25	1,45	120	**31**	11/07/ 1989	3	**4.10**	-
TG 4792	04/08/ 1988	4	44,20	2,23	59	4	43,25	2,38	78	**10**	06/06/ 1989	1	**2.00**	-
TG 4854	04/08/ 1988	4	44,20	2,23	59	1	40,52	3,30	209	**130**	04/08/ 1999	11	**12.20**	-
TG 7111	04/08/ 1988	4	44,20	2,23	59	4	44,30	2,30	147	**55**	02/09/ 1992	4	**5.25**	-
TG 8114	01/09/ 1990	4	44,34	3,07	67	4	39,11	0,46	130	**40**	16/07/ 1994	4	**5.10**	-
TN 69	17/08/ 1990	4	44,41	3,20	65	4	39,20	0,20	138	**48**	17/05/ 1994	4	**4.90**	-
TN 348	25/08/ 1990	4	44,05	3,26	67	4	43,35	1,48	83	**10**	09/07/ 1991	1	**2.10**	-
TN 380	25/08/ 1990	4	43,59	3,53	66	4	36,14	6,07	181	**150**	03/06/ 1997	7	**8.00**	-
TN 411	25/08/ 1990	4	43,59	3,53	62	4	60,04	8,00	213	**172**	06/10/ 1998	8	**9.30**	-
VR 7323	24/11/ 1983	4	37,08	1,48	40	4	36,57	1,52	40	**-**	30/11/ 1983	-	**0.40**	< 1 month at liberty
VR 7326	24/11/ 1983	4	37,08	1,48	34	4	37,05	1,48	34	**-**	30/11/ 1983	-	**0.40**	< 1 month at liberty
VR 7337	24/11/ 1983	4	37,08	1,48	34	4	37,08	1,48	34	**-**	25/11/ 1983	-	**0.40**	< 1 month at liberty
VR 7349	24/11/ 1983	4	37,08	1,48	38	4	37,08	1,48	38	**-**	25/11/ 1983	-	**0.40**	< 1 month at liberty
VR 7401	25/11/ 1983	4	37,09	1,48	40	4	37,09	1,48	40	**-**	27/11/ 1983	-	**0.40**	< 1 month at liberty
VR 7443	25/11/ 1983	4	37,09	1,48	41	4	37,09	1,48	41	**-**	28/11/ 1983	-	**0.40**	< 1 month at liberty

VR 7484	25/11/ 1983	4	37,09	1,48	42	4	37,09	1,48	42	**-**	28/11/1983	-	**0.40**	< 1 month at liberty
YF 969	25/08/ 1990	4	44,00	3,37	65	4	43,34	1,49	86	**13**	17/07/1991	1	**2.10**	-
YF 992	25/08/ 1990	4	44,00	3,37	64	4	43,29	1,37	79	**10**	18/07/1991	1	**2.10**	-
YF 3661	14/10/ 1989	4	43,50	3,17	70	4	44,25	2,30	129	**41**	04/08/1992	3	**4.20**	-
YF 3816	17/08/ 1990	4	44,41	3,20	62	4	43,27	1,47	78	**9**	27/07/1991	1	**2.10**	-
YF 5433	14/10/ 1989	4	43,50	3,17	70	4	43,25	1,40	103	**21**	13/07/1991	2	**3.10**	-
YF 5893	18/08/ 1990	4	44,13	3,21	60	4	43,29	1,51	77	**10**	02/07/1991	1	**2.10**	-
YF 6023	18/08/ 1990	4	44,11	3,11	62	4	44,02	3,05	79	**10**	15/07/1991	1	**2.10**	-
YF 6934	25/08/ 1990	4	44,03	3,30	60	1	38,10	1,30	230	**-**	04/06/2001	11	**12.00**	-
YF 6942	25/08/ 1990	4	44,03	3,30	63	4	43,48	2,17	145	**58**	23/09/1993	3	**4.25**	-
YF 6954	25/08/ 1990	4	44,03	3,30	64	4	44,10	3,13	77	**10**	15/07/1991	1	**2.10**	-
YF 6960	25/08/ 1990	4	44,03	3,30	62	1	44,18	2,20	130	**42**	05/09/1992	2	**3.25**	-
YF 6984	25/08/ 1990	4	44,03	3,30	64	1	44,18	2,20	145	**-**	19/09/1993	3	**4.25**	-
YF 6988	25/08/ 1990	4	44,03	3,30	62	4	43,26	1,46	80	**10**	08/07/1991	1	**2.10**	-
YF 6997	25/08/ 1990	4	44,03	3,30	63	4	43,20	1,40	80	**10**	13/07/1991	1	**2.10**	-
YF 7552	18/09/ 1994	4	39,30	0,12	30	4	39,10	0,07	33	**1**	09/10/1994	-	**0.30**	< 1 month at liberty
YF 7584	24/09/ 1994	4	39,30	0,12	34	4	39,32	0,13	39	**1**	02/10/1994	-	**0.30**	< 1 month at liberty
YF 7593	24/09/ 1994	4	39,30	0,12	30	4	39,39	0,04	36	**1**	30/10/1994	-	**0.30**	< 2 months at liberty
YF 7595	24/09/ 1994	4	39,30	0,12	36	4	39,09	0,04	38	**1**	02/10/1994	-	**0.30**	< 1 month at liberty
YF 7615	24/09/ 1994	4	39,30	0,12	38	1	40,28	0,51	46	**-**	25/10/1994	-	**0.30**	< 1 month at liberty
YF 7617	24/09/ 1994	4	39,30	0,12	38,0	4	39,40	0,04	47	**2**	26/10/1994	-	**0.30**	< 1 month at liberty
ES 6086	22/10/ 1994	4	39,33	0,01	39	1	40,02	0,06	42	**1**	01/12/1994	-	**0.50**	< 2 months at liberty
ES 6008	15/10/ 1994	4	39,35	0,07	38	1	39,54	0,05	46	**2**	01/12/1994	-	**0.50**	< 2 months at liberty
ES 6135	29/10/ 1994	4	39,33	0,01	37	4	39,40	0,10	39	**1**	02/12/1994	-	**0.50**	< 2 months at liberty
ES 1859	30/10/ 1994	4	37,07	1,46	40	4	37,10	1,40	42	**-**	03/12/1994	-	**0.50**	< 2 months at liberty
ES 1922	02/11/ 1994	4	37,04	1,47	40	4	37,30	1,20	40	**1**	03/12/1994	-	**0.50**	< 2 months at liberty
ES 2028	08/10/ 1997	4	39,36	0,04	30	4	44,20	2,48	56	**4**	28/07/1998	1	**1.10**	-

Appendix 2. Recoveries of the western Atlantic superimposed on the curve**.**

REG. NUM ICCAT	TAG	DATE _T	LAT. _T	LONG. _T	FL_T (cm)	LAT. _R	LONG. _R	FL_R (cm)	W _R (kg)	DATE _R	AT LIBER TY (years)	AGE _R	OBSERVA TIONS
6715	D-006205	22/07/ 1965	73, 26 W	39, 22 N	81.28	42, 43 N	70, 25 W	256	397	09/09 1979	14	**16.3**	LJF
51073	H-075281/ H-075282	22/08/ 1978	71, 22 "W	41, 00 N	80	41, 15 N	69, 15 W	**244**	232	28/08 1990	12	**14.25**	**TLE (262)**
91735	H-055672	16/07/ 1976	75, 30 W	36, 50 N	106	43, 10 N	70, 09 W	292	353	26/07 1990	14	**17.2**	FL
132422	H-075400	28/06/ 1980	75, 38 W	36, 35 N	86	42, 50 N	70, 40 W	**229**	177	18/09 1991	11	**14.3**	**TLE (246)**
179323	H-042942/ H-042943	16/07/ 1974	73, 39 W	39, 59 N	53	41, 32 N	69, 40 W	**236**	263	16/08 1989	15	**16.25**	**TLE (254)**
240965	M-002407	07/09/ 1967	72, 06 W	40, 38 N	76.2	42, 20 N	70, 30' W	**253**	272	19/08 1985	18	**20.25**	**TLE (272)**
243591	H-070598/ H-070599	03/07/ 1977	75, 22 W	37, 20 N	78	42, 18 N	70, 25 W	**245**	333	17/08 1988	11	**13.25**	**TLE (264)**
262243	R-086654	13/08/ 1985	71, 00 W	41, 00 N	101.6	42, 40 N	70, 30 W	249	220	03/09 1995	10	**13.3**	FL
267757	H-073108	03/07/ 1977	75, 30 W	37, 11 N	79	43, 22 N	69,49 W	249	299	22/08 1992	15	**17.2**	FL
351006	H-006915	21/07/ 1966	73, 34 W	39, 52 N	78.74	41, 51 N	70, 26 W	262	329	11/09 1979	13	**15.3**	LJF