

DETERMINATION OF LENGTH-WEIGHT EQUATION APPLICABLE TO ATLANTIC BLUEFIN TUNA (*THUNNUS THYNNUS*) IN THE MEDITERRANEAN SEA

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SUMMARY

*The equation describing the length-weight (L-W) relationship, applicable to the Atlantic Bluefin tuna, *Thunnus thynnus*, is extremely important for stock assessment and fisheries managers. Despite the number of works that have been carried out during the last decades, the most recent L-W relationships overestimate the weight attributed to a particular length which would result in an overestimate of the real catch weight. In this study an update of the length's conversion factor is presented ($SFL = 0.69 + 1.0235 * CFL$). Moreover, a new equation obtained from data collected during the fishing season 2018 was determined ($RWT = 1E^{-5} * SFL^{3.1260}$) and in addition a multi-year combined L-W equation applicable to the Mediterranean Sea is also provided ($RWT = 1E^{-5} * SFL^{3.1260}$). Overall, the latest equation resulted slightly different in the estimation of the actual weight of the fish than those proposed by the currently adopted ICCAT equation and the authors recommend to carefully adopt the equation to be used for future stock assessments.*

RÉSUMÉ

*L'équation décrivant la relation taille-poids (L-W), applicable au thon rouge de l'Atlantique, *Thunnus thynnus*, est extrêmement importante pour l'évaluation des stocks et les gestionnaires des pêches. Malgré le nombre de travaux effectués au cours des dernières décennies, les relations taille-poids les plus récentes surestiment le poids attribué à une longueur particulière, ce qui entraînerait une surestimation du poids réel des captures. Cette étude présente une mise à jour du facteur de conversion de la taille ($SFL = 0,69 + 1,0235 * CFL$). En outre, une nouvelle équation obtenue à partir des données collectées pendant la saison de pêche de 2018 a été déterminée ($RWT = 1E^{-5} * SFL^{3.1260}$) et une équation pluriannuelle combinée taille-poids applicable à la mer Méditerranée est également fournie ($RWT = 1E^{-5} * SFL^{3.1260}$). Dans l'ensemble, l'équation la plus récente donne une estimation légèrement différente du poids réel du poisson de celle proposée par l'équation actuellement adoptée par l'ICCAT, et les auteurs recommandent d'adopter avec prudence l'équation à utiliser pour les futures évaluations des stocks.*

RESUMEN

*La ecuación que describe la relación talla-peso (L-W), aplicable al atún rojo del Atlántico, *Thunnus thynnus*, es extremadamente importante para la evaluación del stock y los gestores pesqueros. A pesar del número de trabajos que se han llevado a cabo durante las últimas décadas, las relaciones talla-peso más recientes sobrestiman el peso atribuido a una talla determinada, lo que podría dar lugar a una sobrestimación del peso real de la captura. En este estudio se presenta una actualización del factor de conversión de la talla ($SFL = 0,69 + 1,0235 * CFL$). Además, se determinó una nueva ecuación obtenida a partir de datos recopilados durante la temporada de pesca de 2018 ($RWT = 1E^{-5} * SFL^{3.1260}$) y, asimismo, se presenta una ecuación L-W combinando varios años aplicable al Mediterráneo ($RWT = 1E^{-5} * SFL^{3.1260}$). En general, la estimación del peso real de los peces resultó ligeramente diferente en la última ecuación que la propuesta por la ecuación actualmente adoptada por ICCAT y los autores recomiendan adoptar con precaución la ecuación que se utilizará en futuras evaluaciones de stock.*

KEYWORDS

*Thunnus thynnus, Fisheries, Length-weight relationship,
CFL, SFL, RWT, Mediterranean Sea, Longline*

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1. Introduction

Bluefin tuna (BFT), *Thunnus thynnus*, stock assessment requires the acquisition and analysis of catch-at-size and catch-at-age data from all fishing industry targeting BFT; such analysis is carried out by the Scientific Committee on Research and Statistics (SCRS) which symbolise the scientific arm of the International Commission for the Conservation of Atlantic Tuna (ICCAT).

Biometric studies of length and weight measurements are therefore an essential component for empirical estimates of the BFT catches for two main purposes: carrying out stock assessments to evaluate the state of the wild population and thus the fishing effort to be applied on the stock to avoid overfishing and converting the standard strait fork lengths (SFL) determined by stereocamera (SC) measurements to round weight (RWT) to establish BFT quota allocations and potential over-catches (leading to the requirement of the release of fish from the cages) of purse seine (PS) fish caught in the Mediterranean and then transferred to tuna farms (Deguara *et al.*, 2017).

Stock assessments, made by SCRS for the Atlantic and Mediterranean Bluefin tuna (ABFT), apply different L–W relationships and during the past SCRS Species Group meetings, these equations have been questioned and several new equations have been proposed to the SCRS Working Group (Santos *et al.*, 2004; Aguado-Gimenez & Garcia-Garcia, 2005; Tzoumas *et al.*, 2010; Deguara *et al.*, 2010 and 2012; Galaz, 2012; Cort *et al.*, 2013; Lombardo *et al.*, 2016; Deguara *et al.*, 2017). Cort *et al.* (2015) and Deguara *et al.* (2017) clearly demonstrated that the currently adopted ICCAT model underestimates the weight of BFT at specific periods of the year, in particular when fish are on high fattening condition (K equal or >2). Although comparatively small, these differences turn into a large total weight difference when the whole PS catch (transferred to cages) is calculated (Gordoa, 2017).

In view of the above consideration, the authors of the present study propose an alternative and accurate SFL-CFL conversion factor and a new SFL-RWT equation specifically applicable to the conversion of SFL data to RWT for the Mediterranean Bluefin tuna.

2. Materials and Methods

Data monitoring of the Italian BFT fisheries was carried out by the scientific staff of OCEANIS Srl during the years 2014-2015 and the Department of Life and Environmental Sciences (DiSVA) - Università Politecnica delle Marche, Ancona (Italy) with the support of OCEANIS Srl for the years 2016, 2017 and 2018 within the scientific monitoring program funded by the Italian Ministry of Agricultural, Food and Forestry Policies (MiPAAF), General Directorate of Fisheries and Aquaculture. The area of study covers the longline fisheries targeting BFT in Mediterranean waters around Sicily, Sardinia and the Adriatic Sea.

A total of 9388 specimens were sampled during the 5-years period 2014-2018 and different biometric measurements were collected as: Curved Fork Length (CFL), Strait Fork Length (SFL), Strait First Dorsal fin Length (LD1), Head Length (LH), Gill-Gutted Weight (GG) and Round Weight (RWT).

For the purpose of this study, only data sampled as shown in **table 1** requiring no conversions (for example, from GG to RWT or CFL to SFL) were used and the Fulton's Condition Factor K ($K = 10^5 \cdot \text{RWT} / \text{SFL}^3$) was calculated for this dataset and data in which K was < 1.4 or > 2.6 removed as outliers (Cort *et al.*, 2013).

Thus, a total of 1789 specimen ($\text{SFL} = 62\text{-}297$ cm; $\text{CFL} = 70\text{-}300$ cm) were used for the calculation of the linear relationship of length measurements (SFL-CFL) and a total of 4023 specimens ($\text{SFL} = 87\text{-}297$ cm; $\text{RWT} = 10\text{-}500$ kg) were used for the calculation of the SFL-RWT equation. The coefficient of determination (R^2) was used as index of the quality of the estimates.

3. Results and Discussion

Figure 1 shows the linear relationship between SFL and CFL for the 5-years dataset (2014-2018) used in this study and the SFL-CFL equation obtained is as follows:

$$\text{SFL} = 0.69 + 1.0235 \cdot \text{CFL} \quad (R^2 = 0.9924)$$

Figure 2 presents the SFL-RWT relationship obtained using only the 2018 data and the resulted equation is as follows:

$$\text{RWT} = 1.0\text{E}^{-05} * \text{SFL}^{3.1095} \quad (R^2 = 0.9896)$$

Figure 3 presents the SFL-RWT relationship obtained using the 5-years dataset (2014-2018) and the combined SFL-RWT equation is as follows:

$$\text{RWT} = 1.0\text{E}^{-05} * \text{SFL}^{3.1038} \quad (R^2 = 0.9912)$$

Table 2 shows a quick comparison of the predicted RWT estimated applying the currently adopted ICCAT equation for the East Atlantic stock ($\text{RWT} = 3.50801\text{E}^{-05} * \text{SFL}^{2.878451}$), the equation developed by Deguara *et al.* 2017 ($\text{RWT} = 2.87\text{E}^{-05} * \text{SFL}^{2.9075}$) and the present one ($\text{RWT} = 1.0\text{E}^{-05} * \text{SFL}^{3.1039}$).

The data collected during these past 5 years and the equations obtained can be used as a valuable contribution to the improvement of knowledge in the evaluation of BFT population caught in the Mediterranean and can be incorporated into the catch-at-size analysis and database to be used for future BFT stock assessment sessions. It is also recommended that there be more effort to obtain new and more and more length and weight data from all BFT fisheries in the Mediterranean to increase the dataset available for the SCRS for the determination of an accurate L-W equation applicable to the Mediterranean Sea.

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Table 1. Sampling months of the data used for the analysis in this study.

Year	Sampling month
2014	May-Jun
2015	May-Jun
2016	May-Jun
2017	May-Jun
2018	Jun-Sept

Table 2. Summary and comparison of estimated RWT (kg) from the currently adopted ICCAT equation for East Atlantic stock, from Deguara *et al.* 2017 equation for the Mediterranean Sea and from the present study to the actual weight at a specific SFL (cm).

<i>SFL</i>	<i>Actual Mean RWT</i>	<i>RWT Present study</i>	<i>RWT ICCAT</i>	<i>RWT Deguara et al. 2017</i>
100	18	16	20	19
110	23	22	26	25
120	31	28	34	32
130	38	36	43	40
140	51	46	53	50
150	58	57	64	61
160	71	69	78	73
170	91	84	92	88
180	110	100	109	103
190	129	118	127	121
200	148	139	147	141
210	170	161	170	162
220	200	186	194	185
230	235	214	220	211
240	264	244	249	239
250	275	277	280	269
260	333	313	314	301
270	356	352	350	336
280	400	394	388	374
290	450	440	430	414
300	500	488	474	457

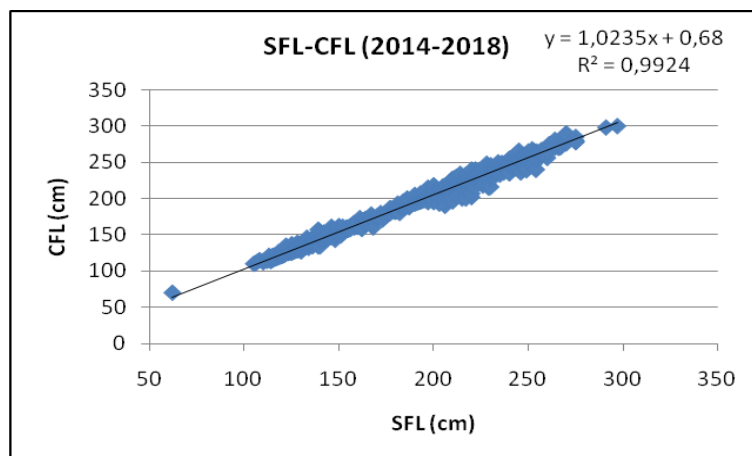


Figure 1. SFL-CFL relationship for Mediterranean Bluefin tuna caught during the 5-years period 2014-2018.

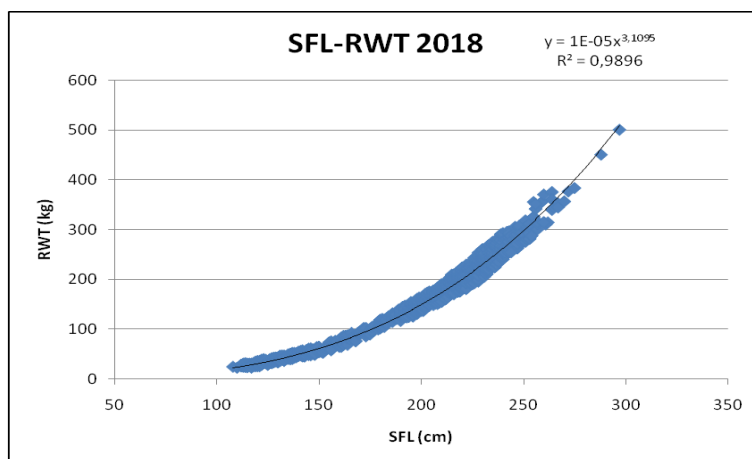


Figure 2. Length-weight relationship (SFL-RWT) for the Mediterranean Bluefin tuna caught during the fishing season 2018.

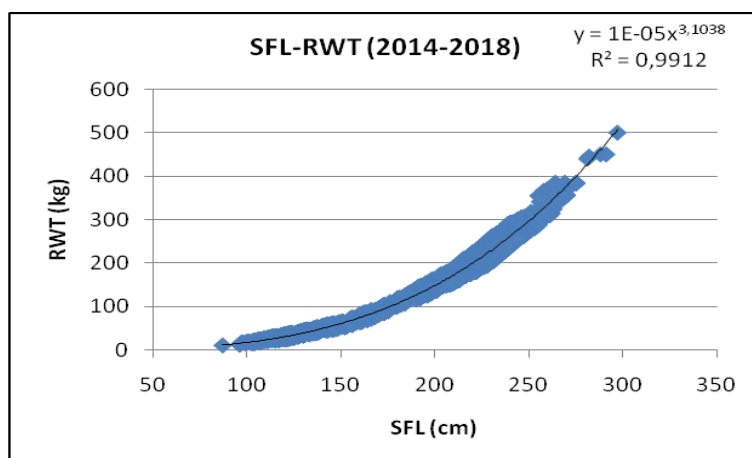


Figure 3. Length-weight relationship (SFL-RWT) for the Mediterranean Bluefin tuna caught during 5-years period 2014-2018.