LENGTH/WEIGHT RELATIONSHIP FOR BLUEFIN TUNA CAUGHT BY LONGLINERS IN CENTRAL MEDITERRANEAN SEA

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SUMMARY

*Length-weight relationships are important parameters in the issue of bluefin tuna stock assessment. An analysis of the data from the Italian longline (LL) fisheries during the months of May and June of the years 2013 to 2015 are presented. Data on length and weight were used from a total of 850 specimens and a new CFL/SFL conversion factor, SFL = 0.9766*CFL - 2.0621 (R^2 = 0.9911), was determined and used for the determination of the following SFL-RWT relationship:*

$$RWT = 9E^{-05}*SFL^{2.6989} \quad (R^2 = 0.8788)$$

RÉSUMÉ

*Les relations taille-poids sont des paramètres importants dans la problématique de l'évaluation du stock de thon rouge. Ce document présente une analyse des données des pêcheries palangrières (LL) italiennes pendant les mois de mai et juin des années 2013 à 2015. Les données de taille et de poids ont été utilisées à partir de 850 spécimens et un nouveau coefficient de conversion CFL/SFL, SFL = 0,9766*CFL - 2,0621 (R^2 = 0,9911), a été établi et utilisé pour déterminer la relation SFL-RWT suivante :*

$$RWT = 9E^{-05}*SFL^{2.6989} \ (R^2 = 0{,}8788)$$

RESUMEN

*Las relaciones talla-peso son parámetros importantes en la evaluación del stock de atún rojo. Se presenta un análisis de los datos de las pesquerías de palangre de Italia (LL) durante los meses de mayo y junio de los años 2013 a 2015. Se utilizaron datos de talla y peso de un total de 850 ejemplares y se determinó un nuevo factor de conversión CFL/SFL, SFL = 0,9766*CFL - 2,0621 (R^2 = 0,9911), y se utilizó para la determinación de la siguiente relación SFL-RWT:*

$$RWT = 9E^{-05}*SFL^{2.6989} \ (R^2 = 0{,}8788)$$

KEYWORDS

Thunnus thynnus, *length-weight relationships, CFL, SFL, Mediterranean Sea, Long lining*

1. Introduction

The historical and socio-economic importance of the Bluefin tuna *Thunnus thynnus* (BFT), its wide geographical distribution, its seasonal variability and the consequence of the overfishing on stocks, ICCAT (2010a), are well documented in many scientific studies, Tiews (1963), Mather *et al.* (1995), Rooker *et al.* (2007), ICCAT (2010b). A plausible and realistic BFT stock assessment requires the acquisition and analysis of capture data from all BFT related fishing activities; 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 Bluefin Tuna (ICCAT).

Biometric studies of Strait Fork Length/Round Weight (SFL/RWT) relationships are therefore important and central to actual estimates of BFT stock assessment and therefore are required to obtain conversion factors for use by fisheries organizations dealing with different type of data.

In spite of the interest of ICCAT in BFT, few SFL-RWT relationships have yet been defined for this species and the current conversion factors used by ICCAT for Atlantic BFT were obtained more than 20 years ago and some of them are not well documented.

Almost yearly, different SCRS documents have been submitted to ICCAT with BFT SFL-RWT relationships for different fishing gears and time and size strata in order to determine catch-at-size for a fishery in a particular year. Due to the wide size range of BFT and the fact that most of the fisheries are limited to certain months of the year, it is difficult to obtain a representative or unique curve for these relationships. Moreover some of the current conversion factors have been called into question, such as that used for the Mediterranean Sea, Alot et al., (2011).

In their estimates for East Atlantic and Mediterranean BFT, up to and including the 2010, the SCRS uses the following equations:

$RWT = (2.95x10^{-5}) \times (SFL)^{2.8990}$ with FL< 101 cm (Rey & Cort, unpublished)
$RWT = (1.9607x10^{-5}) \times (SFL)^{3.0092}$ with FL > 100 cm (Arena, unpublished)

Use of only one equation for each size group is incomplete since the biological parameter K of the fish (Fulton's Condition Factor), generally used as an indicator of the nutritional status of the fish, have been shown to vary at different times of the year, Parrack and Phares (1979), particularly in relation to spawning activity, Santos *et al.* (2004), Deguara *et al.* (2012) and following fattening in tuna cages, Aguado-Gimenez & Garcia-Garcia (2005), Deguara *et al.* (2010) and (2012), Tzoumas *et al.* (2010), Galaz (2012).

In this context, numerous studies have been made for SFL-RWT relationships, Cort *et al.* (2013) and various papers have provided alternative SFL-RWT relationships indicating that the Arena equation does not adequately represent the SFL-RWT relationship for East Atlantic and Mediterranean BFT at specific periods of the year, at different K and in particular during the spawning season.

Such differences in the SFL-RWT relationships between different periods of the year are reflected for the West Atlantic BFT where various relationships are indeed available and used by the SCRS, Parrack and Phares (1979). Two recent papers, Deguara *et al.* (2010) and Alot *et al.* (2011), reviewing some of the data available have made note of this and have called for a more detailed analysis of the SFL-RWT relationships for BFT for the issue of stock assessment. This issue was acknowledged and recognised by the Working Group during the BFT Data Preparatory Meeting held in 2010 which recommended that the various available SFL-RWT relationships be incorporated into the catch-at-size analysis and dataset to be used at future BFT stock assessment sessions, Anon (2011).

In view of the above considerations and following on the SFL-RWT relationship proposed by OCEANIS Srl, in Cozzolino *et al.* (2014), with official Italian TRAP data during the months of May and June 2013, the present authors, as part of the assignment of the Ministry of Agriculture and Forestry - General Directorate of Fisheries and Aquaculture, Italy, for the implementation of the BFT-ROP for the fishing seasons 2013-15, extended the analysis to include the official Italian LL biometric data of BFT caught in the Mediterranean during the months of May and June from 2013 to 2015 for the purpose of carrying out the analysis for the determination of the following SFL-RWT relationship:

$$\mathbf{RWT = 9E^{-05} * SFL^{2.6989}} \quad (R^2 = 0.8788)$$

2. Materials and Methods

Biometric relationships are based on the sampling of BFT catches and landings collected by Observers boarded on LL vessels during the fishing season (15th May - 31st June) for the time period from 2013 to 2015.

Data collection was carried out by the scientific staff of OCEANIS Srl within a non-funded data collection programme.

The area of study covers the fisheries of BFT in waters around Strait of Sicily, Ionian and Tyrrhenian Sea as well as in authorised landing docks.

A total of 850 specimens were measured, weighed out and also different biometric measurements were collected as defined below:

- Curved fork length (**CFL**): the length from the upper jaw (end of the snout) to the fork by an imaginary longitudinal line, corresponding to the fish curvature.
- Strait Fork Length (SFL): the straight line from the end of the upper jaw (end of the snout) to the posterior of the shortest caudal ray (fork of the caudal fin).
- Round Weight (RWT): the weight of the whole fish as it comes out of the water before any treatment or dressing.

The dataset 2015, which provides SFL, CFL an RWT data, was used to work out a new CFL/FL conversion factor that has been compared to the conversion factor adopted by the ICCAT-SCRS for Atlantic BFT: FL = 0.955 * CFL, Parrack and Phares (1979).

Datasets 2013 and 2014, having only CFL data, were all converted into SFL using the conversion factor adopted by ICCAT-SCRS and by OCEANIS Srl.

Allometric equation was used to fit the SFL/RWT relationship, $W = aL^b$, where W (weight) and L (length) are variables and *a* and *b* are parameters. The coefficient of determination (R^2) was used as index of the quality of the estimates.

Graphical analysis of the dataset 2015 was also performed for comparison of the real data collected, ICCAT-SCRS conversion factor and OCEANIS one.

3. Results

A linear CFL/FL conversion factor (**Figure 1**) is obtained and described by the equation:

$$\mathbf{SFL = 0.9766*CFL - 2.0621} \quad (R^2 = 0.9911)$$

The datasets used (2013, 2014 and 2015) and the results of the biometric analyses are reported in **Table 1**.

In each dataset, all the coefficients of determination indices (R^2) obtained by OCEANIS Srl equations were slightly higher than the ICCAT-SCRS one for all the SFL-RWT fits (**Figures 2, 3, 4** and **5**).

The equation for the dataset 2015, based on unconverted SFL data is as follow:

$$\mathbf{RWT = 9E^{-05}*SFL^{2.6989}} \quad (R^2 = 0.8788)$$

The comparison of all the models, considering dataset 2015, showed a better fit between the real data and the OCEANIS equation (**Figure 6**).

4. Conclusions

It is clear that BFT stock assessment requires the acquisition and analysis of capture data from all BFT related fishing activities. In particular, biometric studies of SFL-RWT relationships are very important for the catch-at-size analysis and consequently for BFT stock assessment.

The presented CFL/SFL conversion factor with an outstanding accuracy ($R^2 = 0.9911$) demonstrates the quality of converting CFL into SFL, resulting in a closer estimate of the real SFL of the fish, while the adopted ICCAT-SCRS one underestimates the size of the fish.

The SFL/RWT relationship for Mediterranean BFT obtained in this study is based on three years of data collection during the fishing season 2013 to 2015 and has showed similar (slightly improved) curves and R^2 compared to the equations obtained applying the ICCAT-SCRS CFL/SFL conversion factor.

To be noted that, the comparison of the models (real data vs ICCAT-SCRS vs OCEANIS) showed up a better fit between the real data and the OCEANIS equation suggesting a finer data analysis.

These data and equations can be a valuable contribution to the advancement of knowledge on the population of BFT in the Mediterranean and can be incorporated into the catch-at-size analysis and dataset to be used at future BFT stock assessment sessions.

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Table 1. Summary of BFT length-weight relationships. ICCAT-SCRS refers to datasets where SFL is obtained from FL = 0.955 * CFL (Parrack, Brunenmeister and Nichols, 1979). OCEANIS Srl refers to SFL = 0.9766*CFL - 2.0621.

Sampling year	N	Size range (cm)	SFL/RWT	R^2	Proposed by	Fig.
2013	201	115-252 (CFL)	$RWT = 0.0002*SFL^{2.5454}$	0.8694	ICCAT-SCRS	2
			$RWT = 0.0002*SFL^{2.515}$	0.8696	OCEANIS Srl	
2014	236	132-263 (CFL)	$RWT = 8E^{-05}*SFL^{2.7302}$	0.8624	ICCAT-SCRS	3
			$RWT = 9E^{-05}*SFL^{2.7004}$	0.8626	OCEANIS Srl	
2015	413	115-280 (CFL)	$RWT = 8E^{-05}*SFL^{2.7297}$	0.8786	ICCAT-SCRS	4
		111-271 (SFL)	$RWT = 9E^{-05}*SFL^{2.6989}$	0.8788	OCEANIS Srl	
GROUPED 2013-14-15	850	111-271 (SFL)	$RWT = 7E^{-05}*SFL^{2.7403}$	0.8594	ICCAT-SCRS	5
			$RWT = 8E^{-05}*SFL^{2.7092}$	0.8595	OCEANIS Srl	

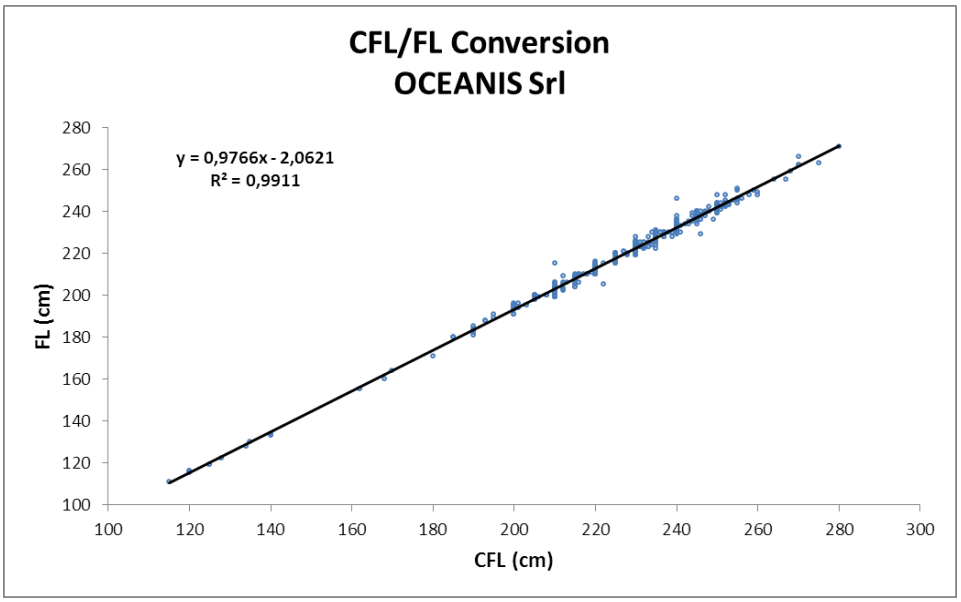

Figure. 1. Dataset 2015. CFL/SFL linear relationship: FL= 0.9766*CFL - 2.0621, R^2 = 0.9911 (OCEANIS Srl).

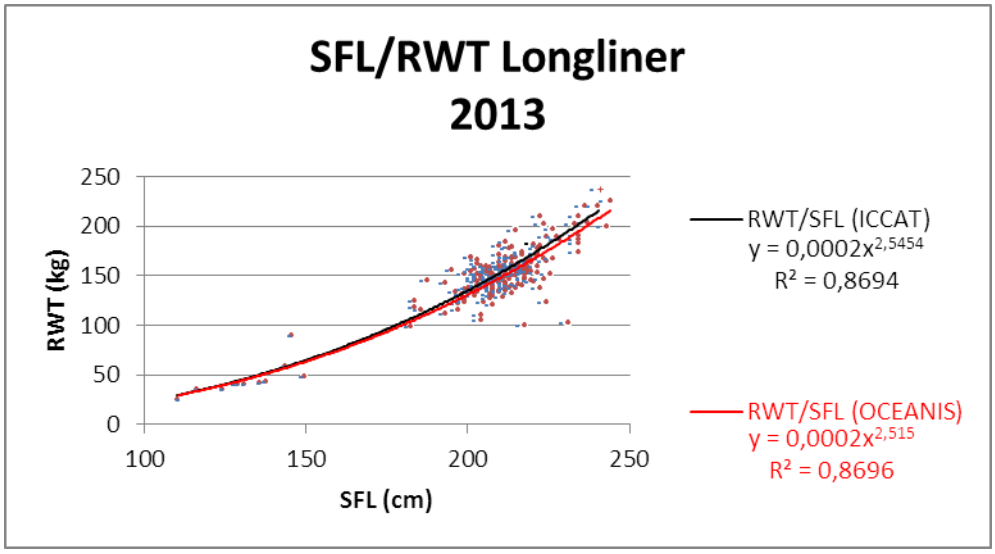

Figure 2. Dataset 2013, Length/Weight relationship. SFL/RWT (ICCAT) curve obtained by conversion factor FL = 0.955 * CFL (black); SFL/RWT (OCEANIS) curve obtained by conversion factor FL= 0.9766*CFL - 2.0621 (red).

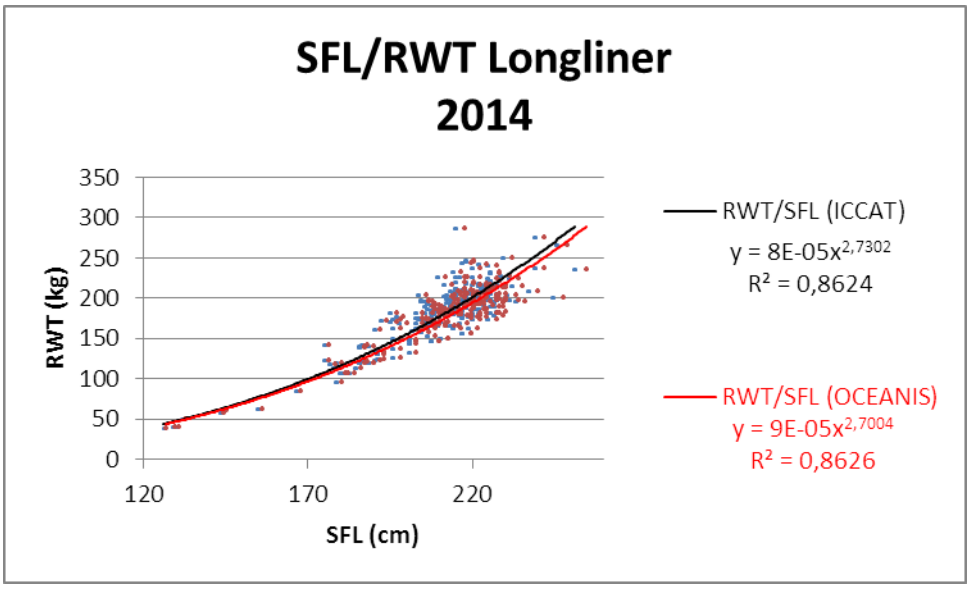

Figure 3. Dataset 2013, Length/Weight relationship. SFL/RWT (ICCAT) curve obtained by conversion factor FL = 0.955 * CFL (black); SFL/RWT (OCEANIS) curve obtained by conversion factor FL= 0.9766*CFL - 2.0621 (red).

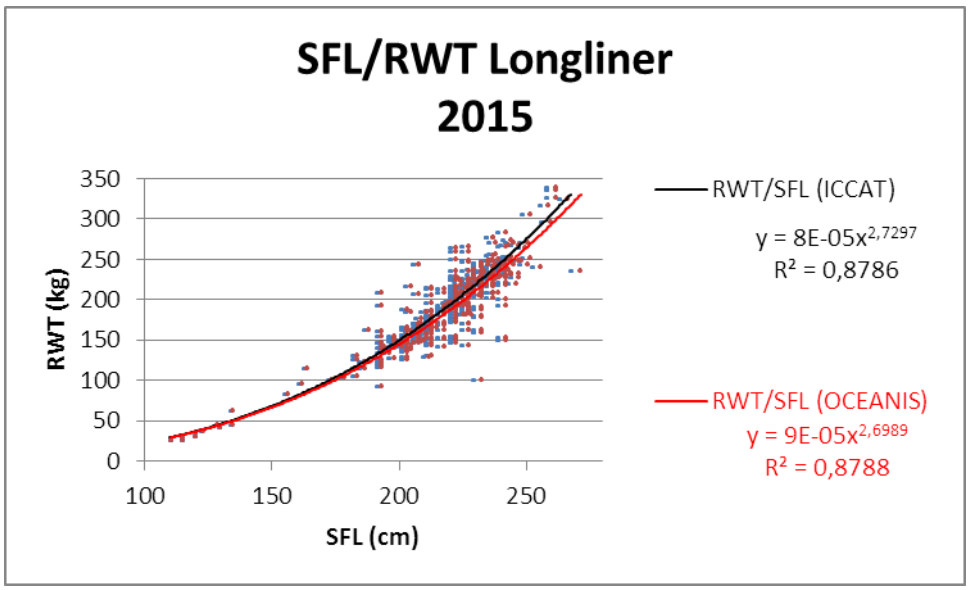

Figure 4. Dataset 2013, Length/Weight relationship. SFL/RWT (ICCAT) curve obtained by conversion factor FL = 0.955 * CFL (black); SFL/RWT (OCEANIS) curve obtained by conversion factor FL= 0.9766*CFL - 2.0621 (red).

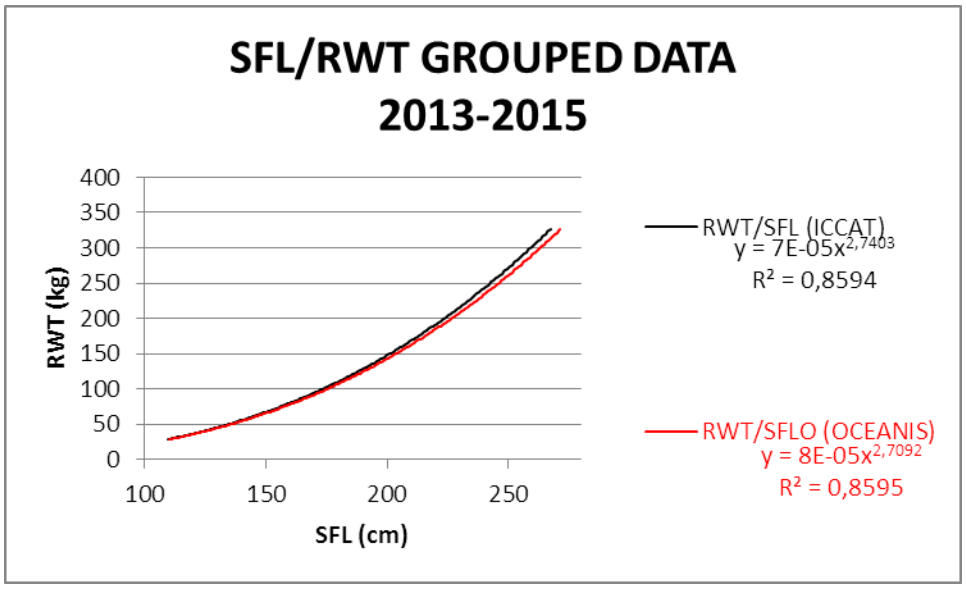

Figure 5. Grouped datasets 2013-15. Length/Weight relationship. SFL/RWT (ICCAT) curve obtained by conversion factor FL = 0.955 * CFL (black); SFL/RWT (OCEANIS) curve obtained by conversion factor FL= 0.9766*CFL - 2.0621 (red).

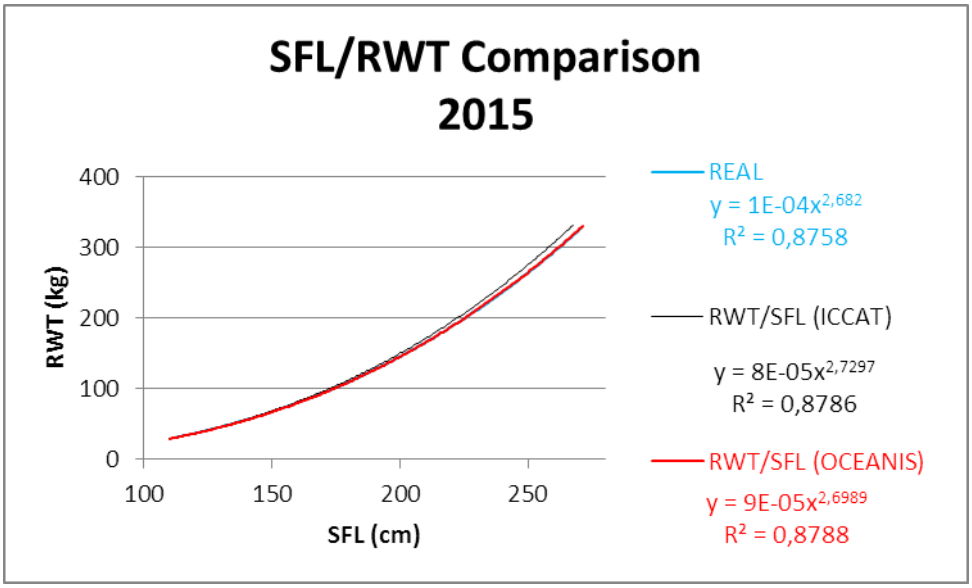

Figure 6. SFL/RWT curve comparison between real data (blue), ICCAT CFL/SFL conversion factor (black) and OCEANIS CFL/SFL conversion factor (red).