LENGTH-WEIGHT RELATIONSHIPS AND A NEW LENGTH CONVERSION FACTOR FOR ATLANTIC BLUEFIN TUNA (*THUNNUS THYNNUS* L.) CAUGHT IN THE MEDITERRANEAN SEA

Paolo Pignalosa[2], Luigi Pappalardo[2], Giorgia Gioacchini[1], Oliana Carnevali[1]

SUMMARY

A total of 1.751 observations of Bluefin tuna (Thunnus thynnus) were carried out by scientific observers employed on board Italian longline fishing vessels (LOA >15 m), on tuna traps and at the main landing ports during the sampling activity in the framework of the National Observation and Monitoring Program. The data were collected from two large areas of the Mediterranean sea along 2019: an Adriatic area opposite to the port of Giulianova and a South Thyrrenian area located between the Aeolian islands, the northern and north-western coast of Sicily.
In this study, new length-weight equations from data collected during the fishing season 2019 were determined (1) and (2) and a new length conversion factor (3) is also provided.
The equations obtained in this study are as follow:

1. **RWT = $(1{,}2691 \times 10^{-5}) * (SFL)^{3{,}0603}$, ($R^2$ = 0,9508)**
2. **GWT = $(1{,}7506 \times 10^{-5}) * (SFL)^{2{,}9908}$, ($R^2$ = 0,9811)**
3. **CFL = (1,0312*SFL)-1,0011, (R^2 = 0,9966)**

Size to weight relationships and weight conversion factor were obtained from the Straight Fork Length (SFL), Round Weight (RWT) and Gutted Weight (GWT) measurements from a total of 1.751 specimens collected from February to June 2019.

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KEYWORDS: Thunnus thynnus, Length-Weight relationship, Bluefin tuna.

[1] *Department of Life and Environmental Sciences (DiSVA), Università Politecnica delle Marche, Ancona, Italy (o.carnevali@univpm.it)*
[2] *OCEANIS Srl, Ercolano (NA), Italy (oceanissrl@gmail.com)*

1. Introduction

The Atlantic Bluefin Tuna (ABFT, *Thunnus thynnus*) is one of the most economically important fish species in the Mediterranean sea. ABFT catches are regulated by the International Commission for the Conservation of Atlantic Tuna (ICCAT) which establishes that each CPC shall ensure coverage by observers on vessels and traps active in the BFT fishery.
The Observation Program has played a key role in the last two years in order to monitor, collect and analyze an high number of biometric and biological data on the large pelagic species.
This work was carried out as part of the National Observation and Monitoring Program funded by Mipaaft (Ministry of Agricultural, Food, Forestry and Tourism Policies - Italy). From a total of 1.751 specimens biometric data were collected from February to June 2019 by the national observers employed by OCEANIS s.r.l. and the scientific staff of the Department of Life and Environmental Sciences (DiSVA) - Università Politecnica delle Marche, Ancona (Italy).
All these measurements different in size allowed to establish the length-weight ratio of ABFT. The activities were carried out both on board of the fishing vessels (LOA >15 m) and at landing harbors where the catches of the small-scale fishing vessel (LOA <15 m) were daily monitored as well as on the traps during the operations of "sacrificio".

However, considering that biometric measurements were collected in very different working conditions, the collection of two kind of weight which are Round weight and Eviscerated weight led to different length-weight relationships.

Length-weight regressions have been used frequently to estimate weight from length because direct weight measurements can be time-consuming in the field (*Sinovcic et al., 2004*). In fisheries research, length-weight relationships are important both for the estimation of weights where only length data are available and also in order to give a valuable contribution for the stock assessment. The length-weight relationship is one of key primary parameters for the stock assessment (*A. Kimoto and T. Itoh., SCRS/2013/075 – Collect. Vol. Sci. Pap. ICCAT, 70(1): 271-283 (2014)*).

2. Materials and Methods

This study is based on scientific data collected by national observers during the Bluefin tuna Fishing Season 2019. These were obtained from the catches of the Italian longline fishing vessels primarily targeting the Atlantic Bluefin tuna (*Thunnus thynnus*) from two main areas of the Mediterranean Sea (**Fig. 1**): an Eastern area located in the central part of the Adriatic Sea and a South Tyrrhenian area located between the Aeolian islands, the northern and north-western coast of Sicily.
They consist in a collection of length and weight measurements taken on individuals, accompanied by the capture date, location, and vessel name.
The scientific observers recorded the straight fork length (SFL), which is the straight line from the end of the upper jaw (end of the snout) to the posterior of the shortest caudal ray and the curved fork length (CFL) which is the curve line from the end of the upper jaw to the posterior of the shortest caudal fin. The processed or round weight (GWT or RWT) was measured and the processed fish is the gulled, gutted, and tailed.
Size was obtained by laying the fish on the vessel floor during the hauling of the fishing gear (on board observation) or at landing ports during the weighing of the tuna.

The length-weight relationship was determined using the equation:

$$W = a L^{b}$$

SFL (L) – Straight Fork Lenght, nearest cm - RWT (W) - Round Weight and GWT (Gutted Weight), nearest Kg - are here considered as distribution factors.
From the total of 1.751 specimens from which biometric data (length, weight etc.) were collected during the entire sampling period from February to June 2019, an amount of 1.371 observations were used in order to obtain the lenght-round weight relationship with its relative equation and the new lenght conversion factor. Furthermore, the gutted weight was sampled only for 407 measurements, which were used in order to provide an update of the L-W relationship. The monitoring activities were also carried out directly onboard the fishing vessels in order to collect biological samples (gonads, second anal fin, liver, blood sample, stomach).
The length and weight data were clustered respectively in 5 cm and 5 Kg intervals in order to estimate the size distributions and, regarding length-weight relationships, the correlation factor (R^2) was used to evaluate the accuracy of the examined equation.

[1] *Department of Life and Environmental Sciences (DiSVA), Università Politecnica delle Marche, Ancona, Italy (o.carnevali@univpm.it)*
[2] *OCEANIS Srl, Ercolano (NA), Italy (oceanissrl@gmail.com)*

3. Results and Discussion

In total 1.751 units were collected with 1.371 lengths (SFL) and 1.646 (CFL) in cm and 1.751 weights (RWT) in kilograms. These represents several monitoring operations performed between February and June 2019. The data correspond to different fishing operations carried out by different type of gears. The monitoring was conducted on traps (Sardinia), longliners (LOA >15 m) and at main landing ports in Italy.

Table 1 shows a summary of the descriptive statistics of the data analyzed in the present study to determine the length-weight equations (2019).

The SFL distribution of 1.371 BFT catches is represented on the basis of the size-lenght classes (cm), for range of 5 cm each (**Fig.2**). The biometric data collected showed a total length ranging from 109 cm to 287 cm (FL) with a mean value of 155,06 cm.
The bluefin tuna size distribution of all data shows a bi-modal trend, with peaks at 135 cm and 220 cm (**Fig. 2**). The first peak refer to classes between 120 cm and 150 cm which account for 68,4 % of the total catches. The second peak refer to classes between 210 cm and 230 cm which account for 12,7 % of the total catches. Data collected on small bluefin tuna were reported by fishing operations from Adriatic Sea carried out between February and April 2019 with fish ranging from 109 cm to 197 cm (**Fig. 3 - blue histograms**), but left-skew towards small fish with a high peak around 135 SFL cm. By comparison information collected on tuna catched in the Tyrrhenian sea from May to June 2019 show a bimodal distribution shape and peaks at 120 cm and 220 cm SFL, but strong right-skew towards big fishes (**Fig. 3 - dark red histograms**). The other size classes all contribute to the remaining 18,9 % of the total catch, especially for classes above the size 235, whose yield is very low.

Fig. 4 – Fig. 5 show the distribution of the catches that is represented on the basis of the size-weight classes (Kg), for range of 5 Kg each. The biometric data collected had total round weight ranging from 19,8 Kg to 419 Kg (RW) with a mean value of 64,94 Kg.
The size-weight classes included between 20 Kg and 60 Kg account for 79,6 % of the total catches. Classes above 60 Kg all contribute to the remaining 20,4 % of the total catch, especially for classes above the size 65 Kg, whose yield is very low.

Fig. 6 shows the annual size distribution of the observed Bluefin tuna (by 5 cm SFL size classes) along the period covered by the National Observation Program (2016-2019). The blue line represents the trend of the average size value observed per year. It shows a rather constant trend with a slight decrease towards 2019. Compared to previous years, monitoring of tuna catches was implemented in February and March 2019 (Adriatic sea). Clearly, the catches observed in this period refer to small-size tuna compared to the others. Increasing the percentage of the smallest size classes sampled (SFL 130-140 cm) consequently the average size observed also slightly decreased.

Fig. 7 represents the SFL-CFL equation obtained for the 2019 catches (n° 1.297 BFT), which is described by the following equation:

$$\mathbf{CFL = (1{,}0312*SFL) - 1{,}0011 \qquad (R^2 = 0{,}9966)}$$

Fig. 8 shows the SFL-RWT relationship and its relative equation obtained for the 2019 catches (n° 1.371 BFT), which is described by the following equation:

$$\mathbf{RWT = (1{,}2691x10^{-5})*(SFL)^{3{,}0603} \qquad (R^2 = 0{,}9508)}$$

Fig. 9 presents the SFL-GWT relationship and its relative equation obtained using the 2019 catches (n° 407 BFT), which is described by the following equation:

$$\mathbf{GWT = (1{,}7506x10^{-5})*(SFL)^{2{,}9908} \qquad (R^2 = 0{,}9811)}$$

[1] *Department of Life and Environmental Sciences (DiSVA), Università Politecnica delle Marche, Ancona, Italy (o.carnevali@univpm.it)*
[2] *OCEANIS Srl, Ercolano (NA), Italy (oceanissrl@gmail.com)*

4. Conclusions

The 1.751 tuna specimen catched by traps and Italian longliners, from which data were collected measuring lengths and weights allowed to appreciate the monthly frequency distribution of both parameters classes.

Despite the number of L–W relationships for the Bluefin tuna developed so far by different authors, the present study proposes a correlation of biometric data (SFL-RWT relationship and a SFL-GWT relationship) for Atlantic Bluefin tuna in order to give a valuable contribution to the advancement of knowledge on the assessment of the tuna population.

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[1] *Department of Life and Environmental Sciences (DiSVA), Università Politecnica delle Marche, Ancona, Italy (o.carnevali@univpm.it)*
[2] *OCEANIS Srl, Ercolano (NA), Italy (oceanissrl@gmail.com)*

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[1] *Department of Life and Environmental Sciences (DiSVA), Università Politecnica delle Marche, Ancona, Italy (o.carnevali@univpm.it)*
[2] *OCEANIS Srl, Ercolano (NA), Italy (oceanissrl@gmail.com)*

Table 1. Descriptive statistic of the data used in the present study (2019).

Descriptive Statistics	SFL-RWT dataset	
	SFL (cm)	*RWT (Kg)*
Mean	155,06	64,93
Median	133,00	41,00
SD	39,36	59,28
Min	109,0	19,80
Max	287,00	419,00

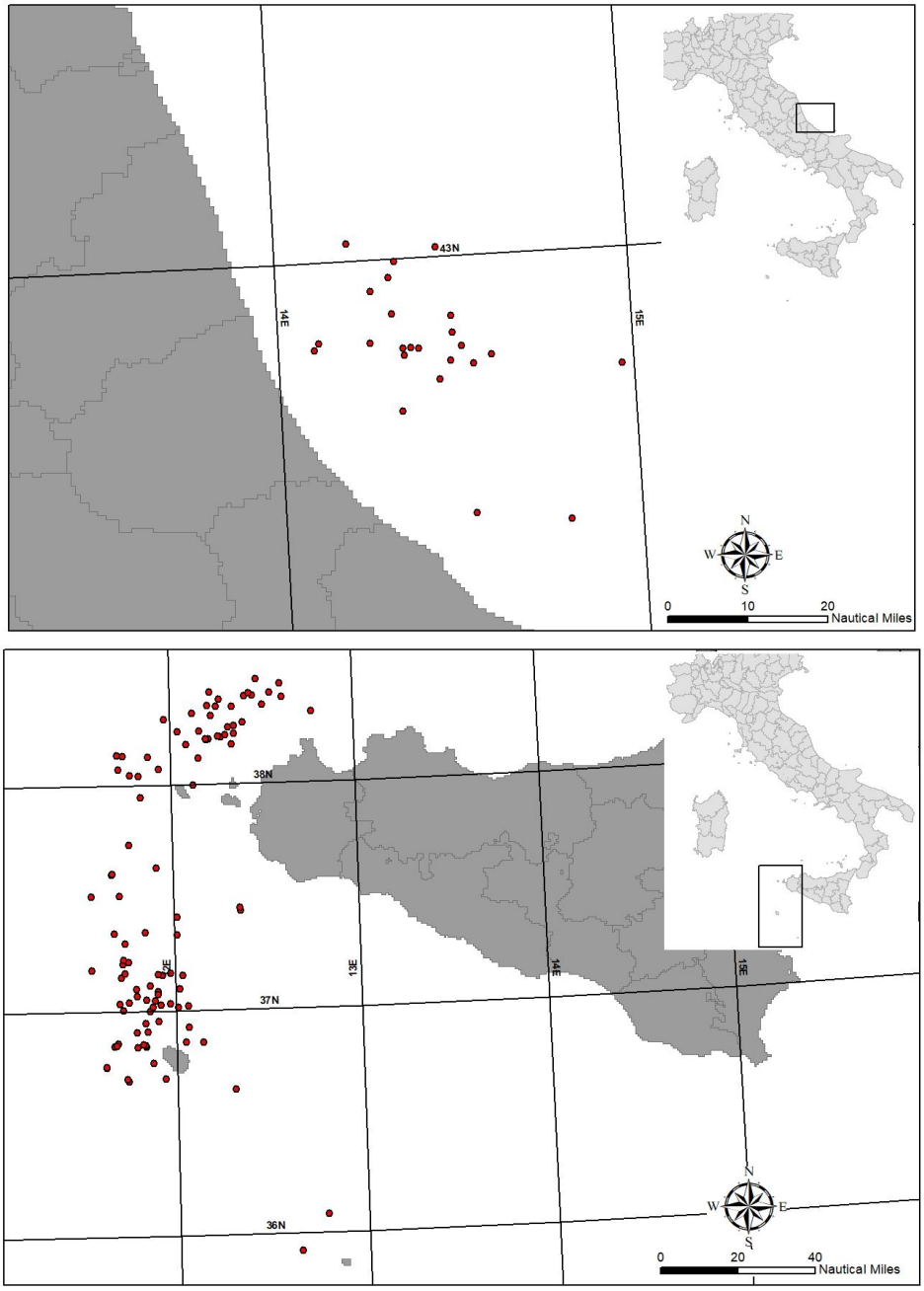

Fig. 1 Geographic localization of the Adriatic (above) and Tyrrhenian (below) catching area for BFT.

[1] *Department of Life and Environmental Sciences (DiSVA), Università Politecnica delle Marche, Ancona, Italy (o.carnevali@univpm.it)*
[2] *OCEANIS Srl, Ercolano (NA), Italy (oceanissrl@gmail.com)*

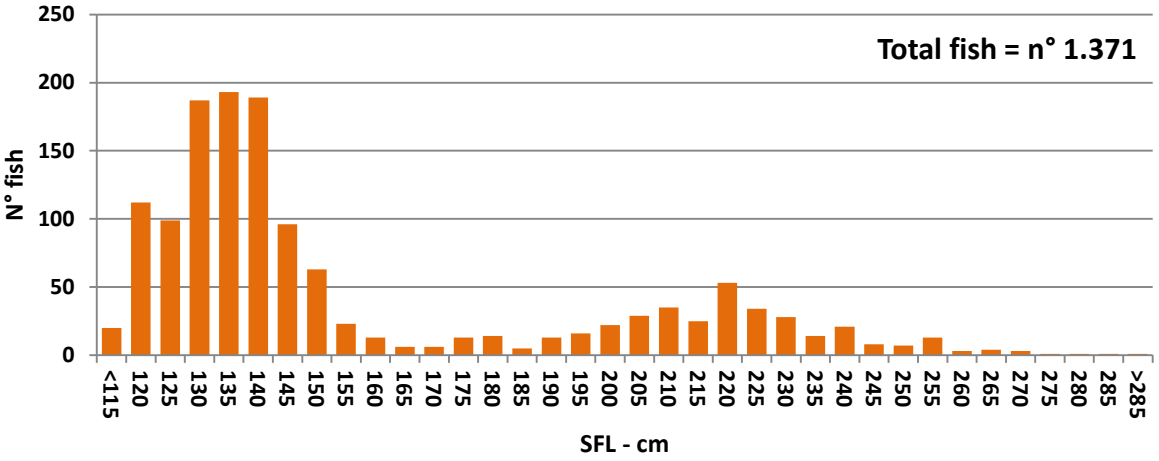

Fig. 2. Length frequency distribution for BFT caught in 2019.

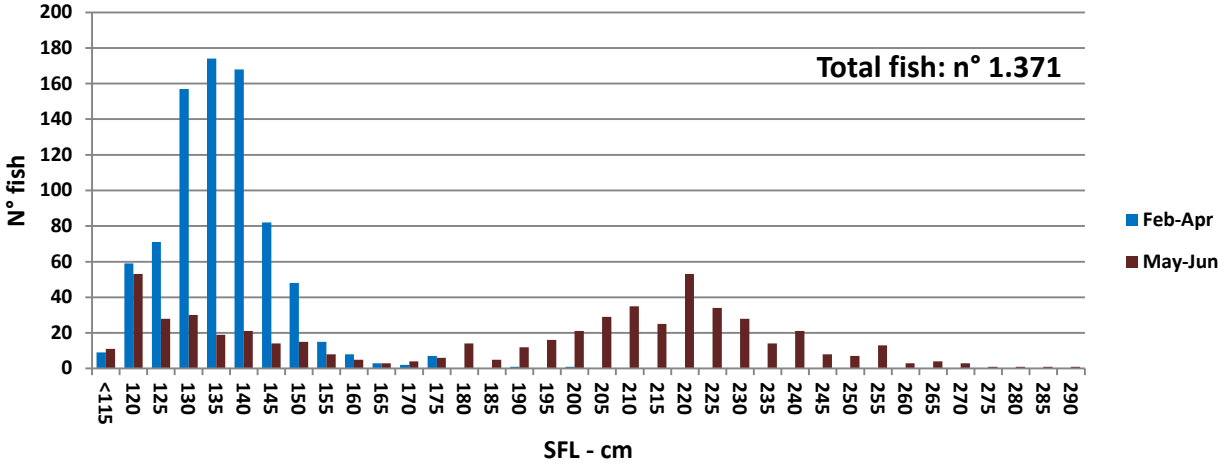

Fig. 3. Length frequency distribution for BFT caught in 2019

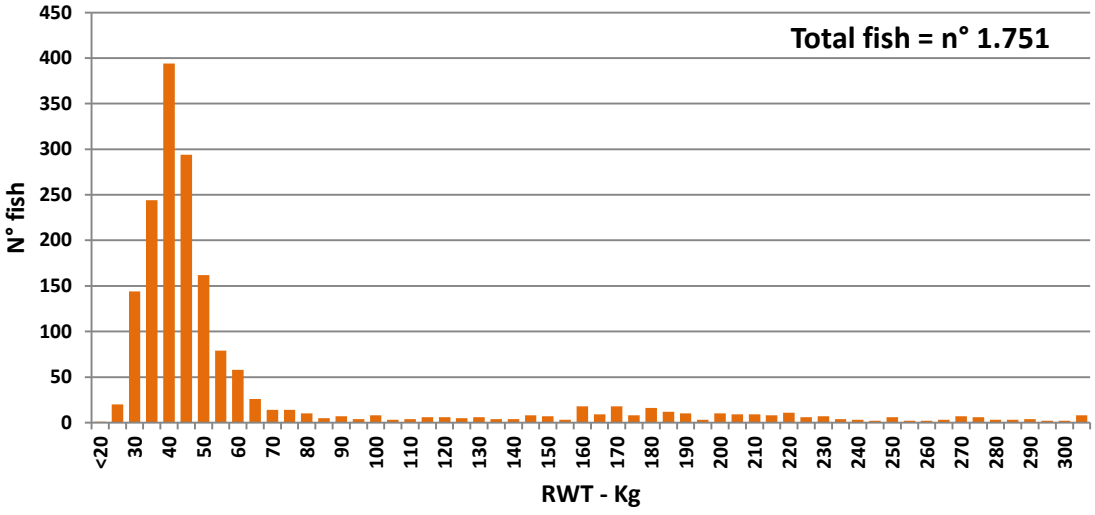

Fig. 4. Weight frequency distribution for BFT caught in 2019.

[1] *Department of Life and Environmental Sciences (DiSVA), Università Politecnica delle Marche, Ancona, Italy (o.carnevali@univpm.it)*
[2] *OCEANIS Srl, Ercolano (NA), Italy (oceanissrl@gmail.com)*

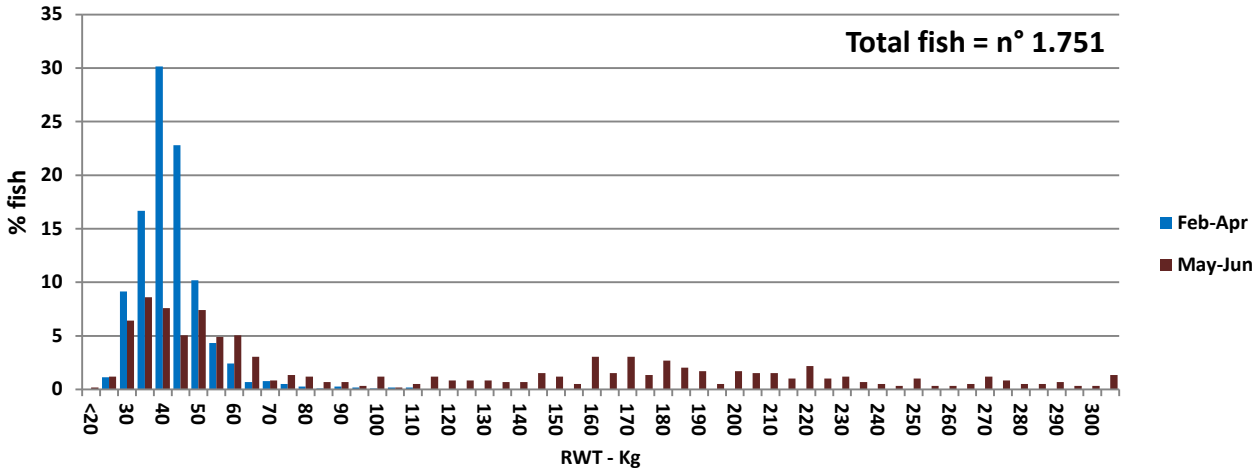

Fig. 5. Weight frequency distribution for BFT caught in 2019

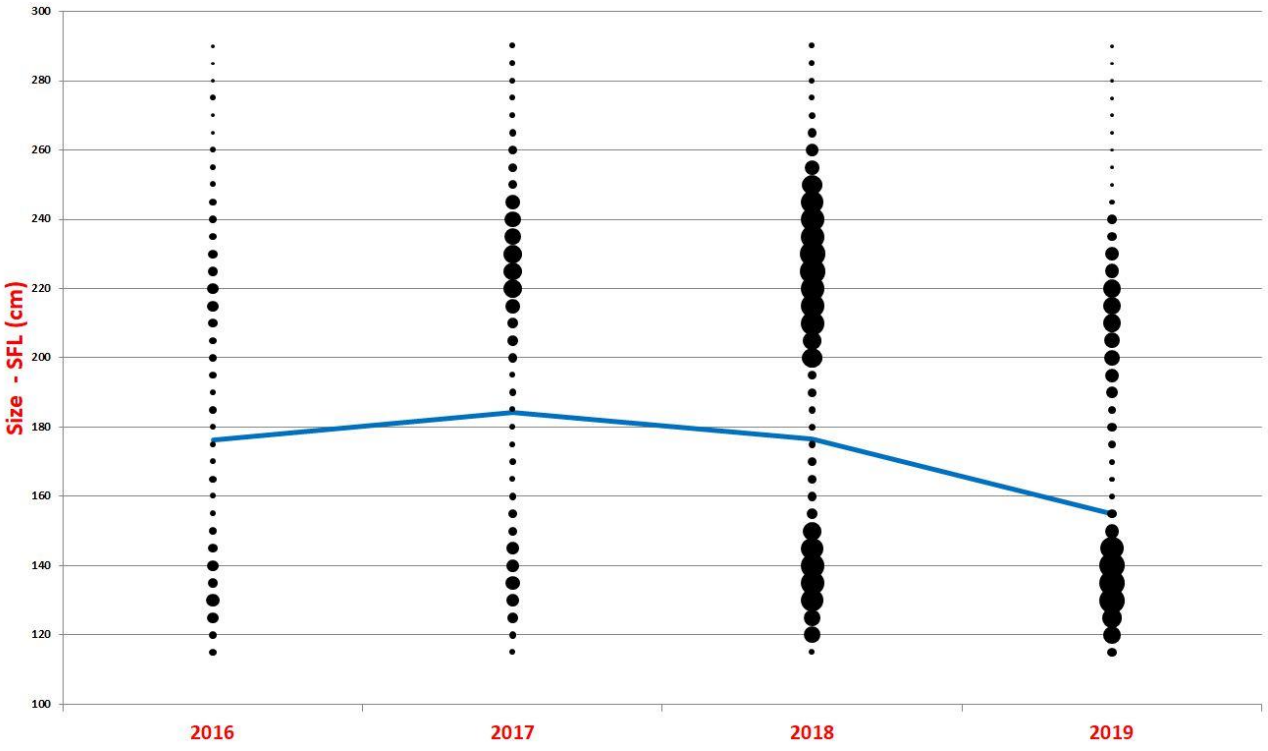

Fig. 6 Annual size distribution of the observed Bluefin tuna (by 5 cm SFL size classes) along the period monitored from 2016 to 2019. The variation of the average size per year is indicated by the trend line in dark blue.

[1] *Department of Life and Environmental Sciences (DiSVA), Università Politecnica delle Marche, Ancona, Italy (o.carnevali@univpm.it)*
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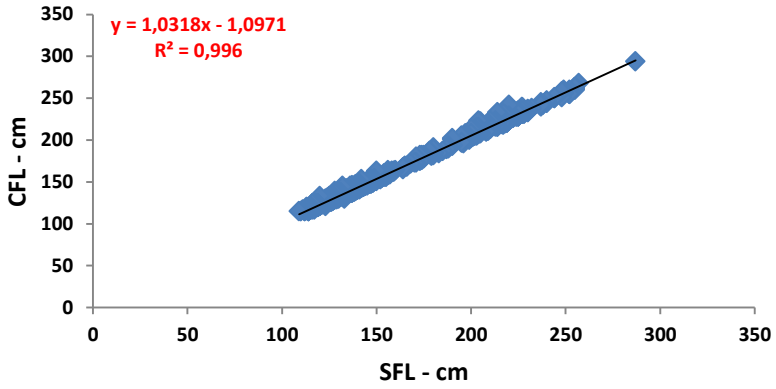
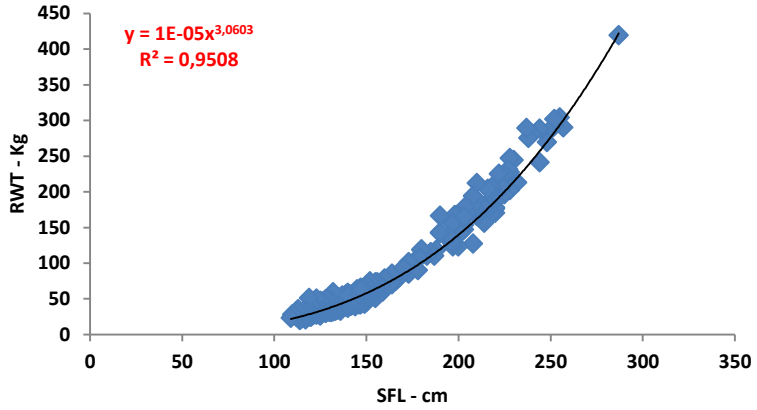


Figure 7. *SFL-CFL relationship (CFL = 1,0312*SFL-1,0011, R^2 = 0,9966) for data collected from February to June 2019*



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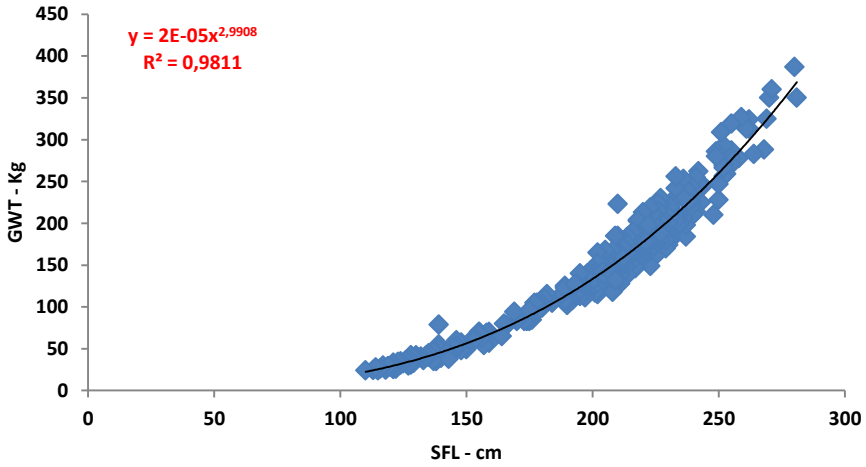

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