

LENGTH-WEIGHT RELATIONSHIPS AND A NEW CONVERSION FACTOR FOR MEDITERRANEAN SWORDFISH (*XIPHIAS GLADIUS* L.) CAUGHT BY LONGLINERS IN THE MEDITERRANEAN SEA

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SUMMARY

*During the year 2019, 1.171 swordfish (*Xiphias gladius*) were sized by scientific observers employed both on board Italian longline fishing vessels and at the main landing ports during the sampling activity concerning the National Observation and Monitoring Program. A total of 6.785 observations of swordfish were carried out from three large areas of the Mediterranean sea along 2018 and 2019: a South Tyrrhenian area located between the Aeolian islands and the north/ north-western coast of Sicily, a coastal Ionian area opposite to the port of Catania and an Adriatic area opposite to the port of Giulianova.*

This work is the final result of the preliminary studies presented by Pignalosa et al. (2018) – SCRS/2019/025 e SCRS/2019/026 and also it updates the work presented by Lombardo et al. (2017).

In this study, a new length-weight equation from data collected during the fishing season 2019 was determined (1), an overall 2-year (2018-2019) L-W equations applicable to the Mediterranean swordfish (2) (3) and a new weight conversion factor (4) are also provided.

The equations obtained in this study are as follow:

1. $RWT = 5E^{-06} * LJF^{3,221}$ ($R^2 = 0,9512$)
2. $RWT = 5E^{-06} * LJF^{3,1979}$ ($R^2 = 0,9401$)
3. $GWT = 2E^{-06} * LJF^{3,3664}$ ($R^2 = 0,9486$)
4. $GWT = 0,8071 * RWT + 0,3195$ ($R^2 = 0,9577$)

Size to weight relationships and weight conversion factor were obtained from the Lower Jaw Fork Length (LJFL), Round Weight (RWT) and Gutted Weight (GW) from a total of 6.785 measurements collected from April 2018 to July 2019.

These results could provide important information for stock assessment studies and fisheries management in the evaluations of the status of this stock. Nevertheless, further similar studies are required to clarify possible differences between sex, areas, seasons and condition factor of this important socio-economic species.

KEYWORDS: *Xiphias gladius*, Length-Weight relationship, Swordfish.

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1. Introduction

Swordfish (*Xiphias gladius* L.) is an important fishery resource for the Italian longline fleet. The National Observation Program has played a key role in the last two years in order to monitor, collect and analyze a high number of biometric and biological data on this large pelagic species.

To establish the relationships between length and weight in swordfish various size data have been collected. The activities were carried out both on board 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.

Since Mediterranean swordfish are usually landed in different conditions, especially in different weight forms such as Round weight (*Mejuto and De la Serna, 1993; Alicli and Oray, 2001; Aliçlı, 2008*) or Eviscerated weight (*De Metrio et al., 1989; Megalofonou et al., 1991a, 1995; Hattour, 1996* etc.), different length-weight relationships were obtained.

Length-weight regressions have been used frequently to estimate weight from length because direct weight measurements can be time-consuming in the field (*Sinovic et al., 2004*).

In fisheries research, length-weight relationships are important for the estimation of weights where only length data are available so that a conversion factor could give a valuable contribution for the stock assessment.

2. Materials and Methods

This work was carried out as part of the National Observation and Monitoring Program funded by Mipaaf (Ministry of Agricultural, Food, Forestry and Tourism Policies – Italy). A total of 1.171 specimens from which biometric data were collected from February to August 2019 by the national observers involved by OCEANIS s.r.l. and the scientific staff of the Department of Life and Environmental Sciences (DiSVA) - Università Politecnica delle Marche, Ancona (Italy), from both onboard observations and landings activities in the main national harbors (Adriatic area, Sicily and South Italy).

Data were obtained from the catches of the Italian longline fishing vessels primarily targeting the Mediterranean swordfish (*Xiphias gladius*) from three main areas of the Mediterranean Sea (**Fig. 1**): a South Tyrrhenian area located between the Aeolian islands and the north/ north-western coast of Sicily, a coastal Ionian area located opposite to the port of Catania and an Adriatic area situated opposite to the port of Giulianova.

Size was obtained by laying the fish out on the vessel floor during the hauling of the fishing gear (on board observation) or at landing port during the weighing of the swordfish.

The length-weight relationship was determined using the equation:

$$W = a L^b$$

LJFL (L) - Lower Jaw Fork Length, nearest cm - which is defined as the distance between the tip of the lower jaw of the fork of the tail (Miyake, 1990), RWT (W) - Round Weight and GWT (Gutted Weight), nearest Kg - are here considered as distribution factors.

Measurements of biometric data (length, weight etc.) were collected from a total of 6.785 units during the entire sampling period from April 2018 to August 2019. Those informations were used in order to provide 2-year equations (2018-2019) for the overall length-weight relationships in respects of the Mediterranean swordfish. Of this total amount, the gutted weight was sampled for a total of 1.402 specimens, which collected size data were used in order to provide an update of the L-W relationship and the new weight conversion factor for the years 2018-2019; although 1.171 units, collected just in 2019, were used in order to obtain the length-round weight relationship and its relative equation.

In collaboration with the maritime authority, for each specimen of swordfish, information on total catches were daily collected at landing, noting several biometric measurements, such as:

- Lower Jaw-Fork Length (LJFL);
- Total Straight Length (FL);
- Gutted Weight (GWT);
- Round Weight (RWT).

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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 sorted by 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 equations.

3. Results and Discussion

A total of 1.171 observations of the size (LJFL, cm) and round weight (RW, Kg) of Mediterranean swordfish were collected from February to August 2019.

Table 1 shows a summary of the descriptive statistics of the data analyzed in the present study to determine the LJFL-RWT equation (2019).

The distribution of the swordfish catches (2019) is represented referring to the size-length classes (cm), for range of 5 cm each (**Fig. 2**). The biometric data collected had total length ranging from 80 cm to 225 cm (LJFL) with a mean value of 133,87 cm.

20 specimens of swordfish (1,70%) were landed with size value below the limit of the undersized swordfish established by ICCAT.

The Mediterranean swordfish size distribution of all data shows a bi-modal trend, with peaks at 130 cm and 180 cm (**Fig. 2**). The first peak refers to classes between 105 cm and 135 cm which account for 65,20 % of the total catches. The second peak refers to classes between 170 cm and 195 cm which account for 13,80 % of the total catches. The other size classes all contribute to the remaining 19,30 % of the total catch, especially for classes above the size 195, whose yield is very low.

Fig. 3 shows the distributions of the catches represented on the basis of the size-weight classes (Kg), for range of 5 Kg each (**Fig. 3**). The biometric data collected had total round weight ranging from 6,2 Kg to 170 Kg (RW) with a mean value of 37,56 Kg.

The size-weight classes included between 10 Kg and 35 Kg account for 63,40 % of the total catches. Classes above 35 Kg all contribute to the remaining 36,60 % of the total catches, especially for classes higher to 80 Kg whose yield is very low.

Fig. 6 represents the LJFL-RWT equation obtained for the 2019 catches, which is described by the following equation:

$$RWT = 5E^{-06} * LJF^{3,221} (R^2 = 0,9512)$$

Considering all database, fish size ranges from 78 to 230 cm LJFL with a mean value of 129,12 cm and from 6,2 to 170 RWT Kg with a mean value of 33,34 Kg (RW). However, sizes between 100-130 cm LJFL represent 62,52 % of the total catches and weights <30 Kg represent 60,85% of the total catches (**Fig. 4** and **Fig. 5**). **Fig. 7** shows the final LJFL-RWT equation obtained using the 2-years dataset (2018-2019), which is described by the following equation:

$$RWT = 5E^{-06} * LJF^{3,1979} (R^2 = 0,9401)$$

Fig. 8 presents the LJFL-GWT equation obtained using the 2-years dataset (2018-2019), which is described by the following equation:

$$GWT = 2E^{-06} * LJF^{3,3664} (R^2 = 0,9486)$$

Fig. 9 shows the linear relationship between RWT and GWT for the 2-years dataset (2018-2019) used in this study and the RWT-GWT equation obtained is as follows:

$$GWT = 0,8071 * RWT + 0,3195 (R^2 = 0,9577)$$

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4. Conclusions

From a total of 6.785 units measurements on swordfish caught and landed by the Italian longline fleet were collected by national observers in order to appreciate the monthly frequency distribution of size length and weight classes of the fished swordfish.

In the Italian Mediterranean, the swordfish caught size falls within a range of 78 cm to 230 cm with an average length of 129,12 cm.

Despite the number of L–W relationships for the Mediterranean swordfish developed so far by different authors, the present study proposes a correlation of biometric data (LJFL–RWT relationship and a 2-year L–W relationship) for Mediterranean swordfish in order to give a valuable contribution to the improvement of the assessment regarding the swordfish population in the Mediterranean Sea.

In regard of the monthly size and weight frequency distribution, our results showed a high percentage of small swordfish catches during all the sampling period, April 2018 to July 2019 (LJFL 100–130 cm and <30 Kg RWT) which, on the basis of our new findings regarding the size at first maturity of this species (data not included), should be considered for further management scenario evaluations as recommendation for the minimum catch-at-size.

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

Descriptive Statistics	LJFL-RWT dataset (n=1.171)	
	<i>LJFL (cm)</i>	<i>RWT (Kg)</i>
Mean	133,87	37,56
Median	128,5	30,0
Min	80,0	6,2
Max	225,0	170,0

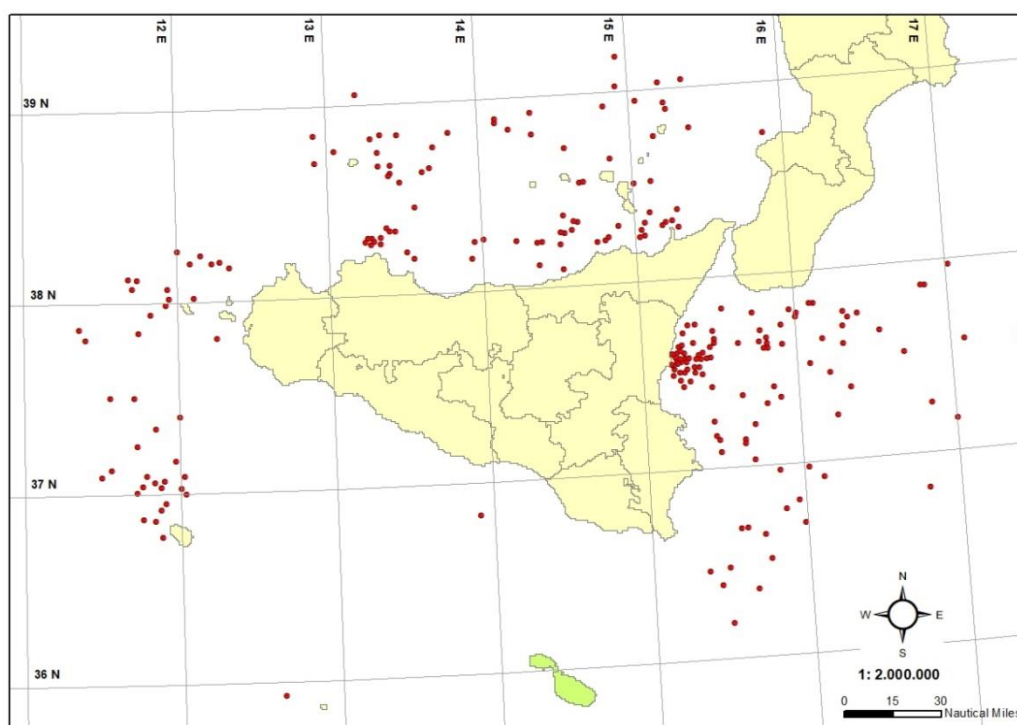


Fig. 1. Distribution of the catches which were observed during the sampling period (April 2018 – August 2019).

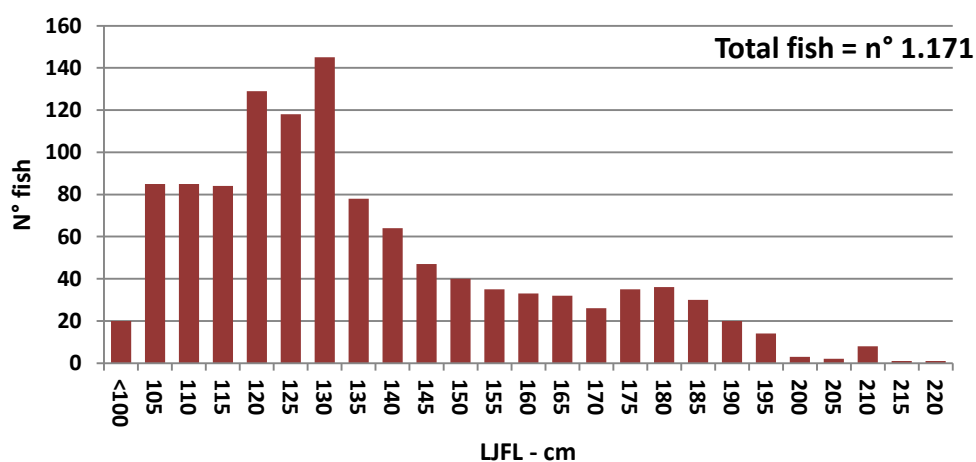


Fig. 2. Length frequency distribution for swordfish caught in 2019

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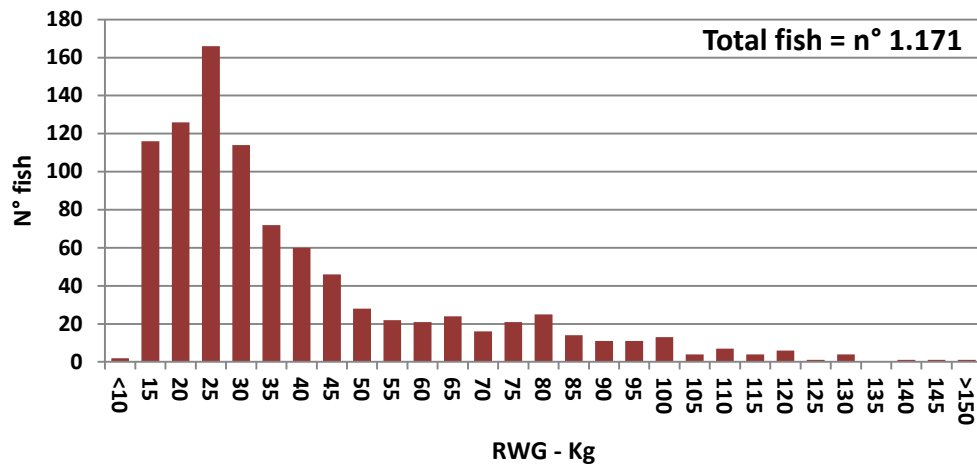


Fig. 3. Weight frequency distribution for swordfish caught in 2019.

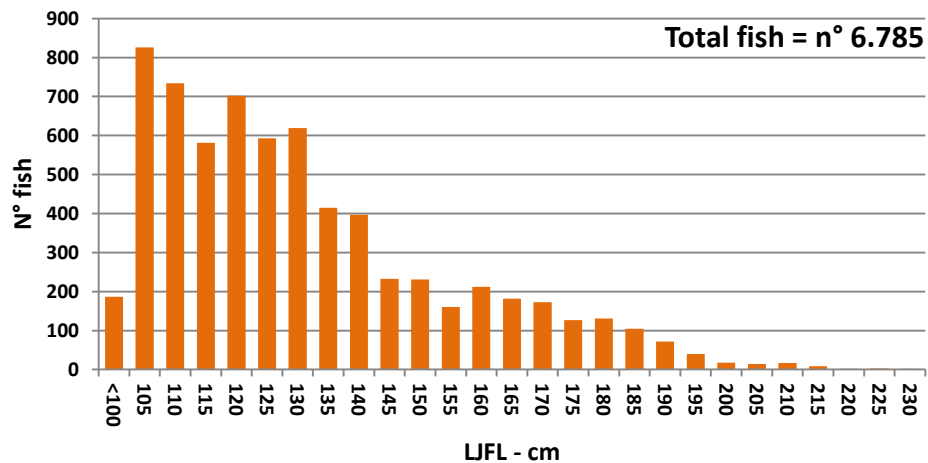


Fig. 4. Total 2-years Length frequency distribution for Mediterranean swordfish (2018-2019).

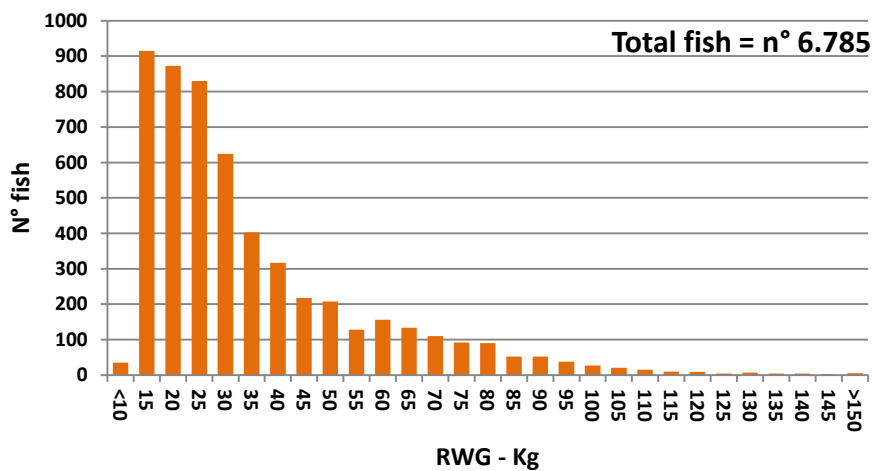


Fig. 5. Total 2-years Round weight frequency distribution for Mediterranean swordfish (2018-2019).

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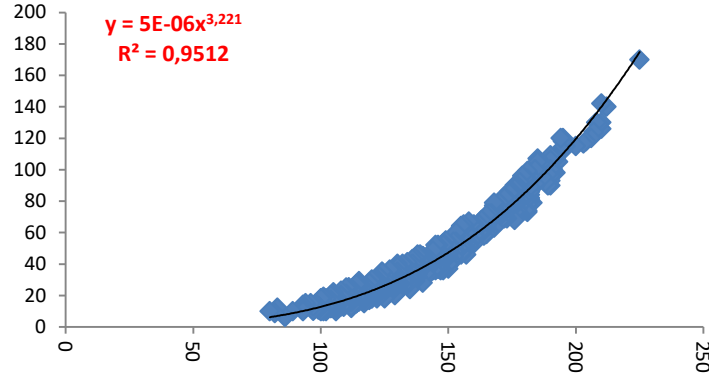


Figure 6. LJFL-RWT relationship ($RWT = 5E^{-06} * LJF^{3,221}$, $R^2 = 0,9512$) for data collected from February to August 2019

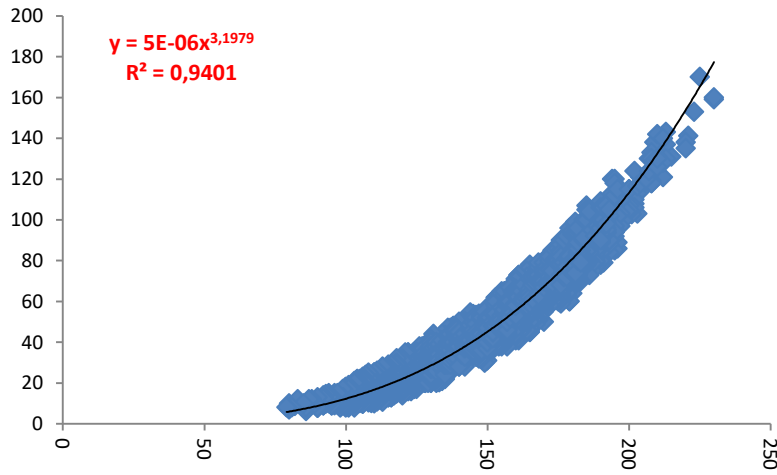


Figure 7. Total 2-years LJFL-RWT relationship ($RWT = 5E^{-06} * LJF^{3,1979}$, $R^2 = 0,9401$) for the Mediterranean swordfish (2018-2019)

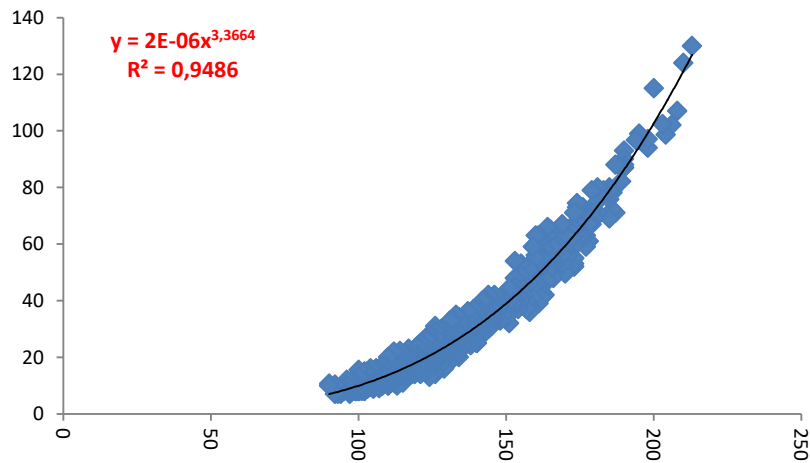


Figure 8. Total 2-years LJFL-GWT relationship ($GWT = 2E^{-06} * LJF^{3,3664}$, $R^2 = 0,9486$) for the Mediterranean swordfish (2018-2019)

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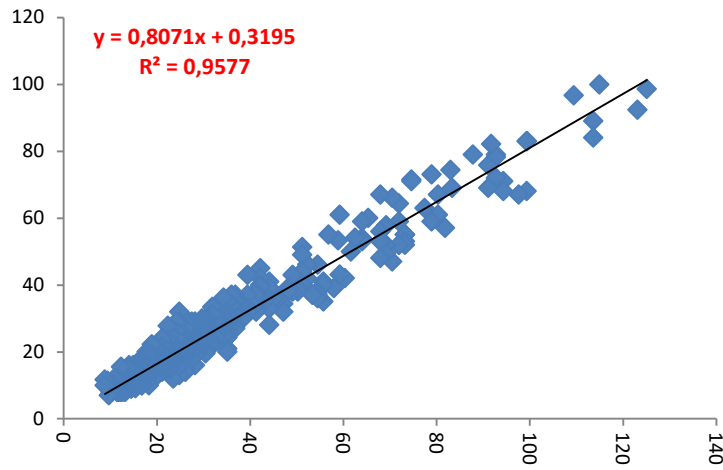


Figure 9. Weight conversion factor ($GWT = 0,8071 \cdot RWT + 0,3195$, $R^2 = 0,9577$) for the Mediterranean swordfish (2018-2019)

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